

**OFFICIAL**

A. E. F. No. 1475-2  
G-5

# **GAS MANUAL**

Part II

## **Use of Gas by the Artillery**

General Headquarters  
American Expeditionary Forces, France  
March, 1919

GENERAL HEADQUARTERS  
AMERICAN EXPEDITIONARY FORCES

*March, 1919.*

The "Gas Manual" in six parts is approved and published for the information and guidance of the American Expeditionary Forces. Although this manual presents the practice in the American Expeditionary Forces, its publication is not intended to convey approval for adoption in the future military service of the United States of any details of organization contained herein.

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# **GAS MANUAL**

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## **PART II**

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### **USE OF GAS BY THE ARTILLERY**

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#### **INTRODUCTION.**

1. The information in this part of the Gas Manual on the use of gas in artillery shell, is compiled with the certain definite purpose of furnishing the artilleryman and the gas officer concise information on the use of chemical ammunition. All subject matter which is covered in other chapters of this pamphlet and any documents or pamphlets compiled by the American Expeditionary Forces dealing with the subject of artillery firing, has been omitted. Information contained in other chapters treating in detail on the characteristics of gases, their tactical use, gas defense and gas training, will, however, be useful.

2. *Information.* In accordance with Par. 1, G. O. No. 107, G. H. Q. A. E. F., 1918, gas officers will be consulted preparatory to the offense use of gas on a large scale. In order that the gas officer may give intelligent advice, information must be furnished him on the following points:

#### **Information of the Enemy:**

- (1) Points of concentration.
- (2) Strong points.
- (3) Battery positions.
- (4) Reserves.
- (5) Dumps.
- (6) Lines of communication.

#### **Information of Our Own Troops:**

- (1) Positions.
- (2) Plan of action.
- (3) Location of batteries.
- (4) Number of guns.
- (5) Caliber of guns.
- (6) Quantity of ammunition available.
- (7) Kind of ammunition.

3. The Gas Officer must make a careful study of the topographical features of the terrain and the meteorological conditions applying. After a solution has been arrived at, the Gas Officer must be able to advise definitely the Chief of Staff or Artillery Commander as to the following:

- (1) Location of target.
- (2) Time of shoot.
- (3) Rate of fire.
- (4) Kind of gas shell.
- (5) Number of gas shell required.
- (6) Object to be accomplished.

4. The effective range of a gun must be considered, and, therefore, its position as regards distance from available targets must be known.

5. The volume of fire which can be placed on a position is limited by the quantity of gas shell on hand, and by the percentage of all gas shell fired which will fall within an effective distance of the same. This last crosses the line of demarcation of the duties of a Gas Officer and of an Artillery Commander, and the latter must be consulted by the former, so that impossible solutions are not arrived at.

6. Shrapnel, H. E. and gas shell each has its distinctive uses and in many cases efficient results cannot be obtained by substitution. If the artilleryman understands the simple rules governing the use of gas shell, he has an excellent weapon at his command, and its proper use incurs no danger to his men or to others of our own forces.

7. *Safe Dose of Mustard Gas.* The following table gives the maximum number of rounds of H. S. which may be fired without endangering our own troops. The greater the range the more can be safely used.

Rounds per 100 meters front.

SIZE OF SHELL	LBS. OF GAS	500 METERS	1000 METERS	2000 METERS	3000 METERS AND BEYOND
75 mm.....	1.35	6	15	50	100 or more
4.7" G.....	4.2	3	9	30	60 or more
5" S. C.....	5.10	2	6	20	40 or more
6" S. C.....	10.1	1	3	10	20 or more
155 mm.....	10.35	1	3	10	20 or more
8" How.....	21.6	..	..	4	8 or more
9.2" How.....	28.3	..	..	3	6 or more
9.5" How.....	36.1	..	..	2	3 or more

8. In shelling an area with mustard gas you need not use more than one 75 mm. shell for each 25 square meters (5 meters square), and for larger shell you can use proportionately less.

9. At ranges less than 2,500 meters, the firing should not be repeated with mustard gas oftener than once every six hours. Indeed, it is hardly ever necessary to repeat mustard gas firing at more frequent intervals. Chlorpicrin and similar moderately persistent gases may be fired in double the above quantities and at intervals of half the time shown above. With phosgene and similar lethal low-persistent gases,  $2\frac{1}{2}$  times as much may be fired and repeated at intervals of one hour or even less, though not oftener than every 30 minutes. For Group IV, fire  $1\frac{1}{2}$  as much as for mustard gas and repeat not oftener than every 4 hours.

#### 10. Miscellaneous Hints.

(a) Use instantaneous fuse; either French IAL or American Mark III.

(b) The largest angle of fall possible is desired.

(c) Secure enfilade fire whenever possible so gas cloud will reach as many of enemy as possible.

(d) H. E. or shrapnel should accompany gas shell whenever possible. They add to the confusion of the enemy and camouflage the use of gas. They do not appreciably dissipate the gas clouds.

#### 11. Zones in front of our own lines within which it is dangerous to place shell.

	WIND BLOWING TOWARD ENEMY.	WIND BLOWING TOWARD OUR LINES.
Non-Persistents.		
Small Quantity .....	300 meters	1000 meters
Large Quantity .....	300 meters	2000 meters
Persistents.		
Small Quantity .....	1000 meters	1000 meters
Large Quantity .....	2000 meters	2000 meters

If you do place shell within these zones, study the matter carefully and be sure to warn our own troops so that masks may be worn and other precautions taken, including temporary evacuation if advisable.

#### 12. Fire for Adjustment.

(a) For adjustment use special liquid smoke shell (marked with 2 yellow bands). When special smoke shells are not available, H. E. shell may be employed for ranging, in which case correction must be made for the difference in ballistic coefficient between the solid filled H. E. Shell and the liquid filled gas shell. For 75 mm. caliber the difference in range between H. E. and gas shell is negligible at 2000 meters, but at 7000 meters gas shell range short of H. E. by 200 meters. At ranges between 2000 and 7000 the difference may be taken as proportional. Range differences for other calibers of shell will be published as soon as available.

(b) Adjustment in gas shelling should be done on a datum point in the same general direction and at approximately the same range as the target but sufficiently distant therefrom so as not to attract attention, as effective gas bombardment must set in suddenly. If the cessation of the bombardment is covered by a repetition of shelling of individual objectives (possibly with a fewer number of shots), the timely reinforcement of the enemy is then hindered. The enemy will also be obliged to wear his gas mask longer.

(c) Use firing tables for Semi-Steel Shell (Fonte acierée)—with fuse wherever special tables for Gas Shell are not provided.

(d) Accuracy of fire is essential.

(A) Correct for differences in weight when substituting gas shell for H. E. or Smoke Shell.

(B) With Non-Persistent Gases. Seek narrow bracket; if there is no wind adopt mean angle of elevation of bracket in fire for effect. If there is a wind, modify the mean angle of elevation by  $1/6$  fork to the windward.

(C) With Persistent Gases. Seek narrow bracket and adopt mean angle of elevation regardless of wind direction.

### 13. *Fire for Effect.*

(a) *With Non-Persistent Gases.* Execute Precision Fire. On targets of depth repeat fire every 100 meters in depth.

(b) *With Persistent Gases.* Execute Zone Fire.

## EXPENDITURE OF MUNITION.

14. *To ascertain number of guns and rounds required to gas an enemy position,* see Appendix, C. G. chart Fig. 1. The following notes show how to use the chart.

15. *For Non-Persistent Gases (Phosgene).* Since intense rate of fire is necessary to obtain effective concentration of gas, it is as important to know the number of guns required as well as the number of rounds necessary.

(a) Determine range and front of objective.

(b) Locate intersection of the range ordinate, and the curve for the calibre of gun chosen.

(c) Project to the right and read number of guns required for each fifty meters front, firing at "R" rate of fire.

(d) Multiply this number of guns by the number of times 50 is contained in the objective front measured perpendicular to the direction of the wind, to get the total number of guns.

(e) Number of guns  $\times$  R  $\times$  2 equals expenditure of ammunition.

(f) Carry fractions through to end of computations but take result in round numbers.

(g) If mixed calibers are to be used because of being available determine effective kilograms of gas to be had from one gun as read at left and combine guns to give the total lethal dose.

(h) If P. S. is used for lethal effect, expenditure of ammunition should be at least that for C. G.

16. *For Persistent Gases (Mustard Gas).* (See Appendix, H. S. Chart Fig. 2). Since intensity of fire is not necessary for these gases, the number of guns used is unimportant—the total rounds fired being the only figure necessary to obtain. Hence the above calculation simplifies as follows:

(a) Determine range and area to be covered and read direct from chart number of rounds required for each area 100 meters square.

(b) If P. S. is used in place of H. S., expenditure of ammunition should be the same.

17. *For Lachrymatory Gases.*

(a) With brombenzylcyanide (C. A.) use  $1/20$  as many rounds as given by the chart for H. S.

(b) When firing chlorpicrin (P. S.) for lachrymatory effect, use  $1/4$  as many rounds as given by the chart for H. S.

(c) To maintain the lachrymatory atmosphere with brombenzylcyanide continue to fire every four hours the same amount as fired at first. That is, give the same dose every four hours.

(d) If chlorpicrin is used, repeat the original dose every hour.

Whenever enough ammunition is available use a "factor of safety," by doubling the amounts obtained from the chart. This will make up for unknown factors such as local wind currents at enemy position, etc.

## METEOROLOGICAL AND TOPOGRAPHIC CONDITIONS.

### 18. *Meteorological.*

(1) *Stability of Air.* In dry, sunny weather, upward air currents are usually present. They rapidly dissipate gases. Therefore, a warm, sunny day is not a particularly good time in which to fire gas. The best time to fire gas is usually at night, because the atmosphere then is relatively stable. In the case of a persistent gas, as soon as the sun comes up the heat causes the liquid on the ground and foliage to vaporize, thereby increasing the concentration.

(2) *Fog.* Foggy days are usually excellent for firing gas, for the atmosphere at such times is fairly stable.

(3) *Rain.* Very heavy rain washes down all gases and is a considerable disadvantage. Very light rains or drizzles are often beneficial.

(4) *Barometer.* With a low barometer, the air near the surface is full of "pockets" and upward currents which may dissipate the gas.

(5) *Temperature.* A low temperature lessens the concentration of persistent gases since the liquid evaporates more slowly. The highly lethal, non-persistent gases are not much affected by a low temperature.

(6) *Time.* For persistent gases, any hours are good, though the hours after midnight are best. Their best effects are obtained during the weather familiarly termed "warm and muggy," which is warm enough to cause the gas to rise freely, when the heavy air assists their penetrative action by causing the gas clouds to spread.

(7) *Winds.* Winds have a considerable influence. Generally, toxic gases of low persistency should be limited to velocity not exceeding ten miles per hour ( $4\frac{1}{2}$  meters per second). Limit persistent and tear gases to wind velocity not exceeding 20 miles per hour (9 meters per second).

The ideal weather conditions are usually found on summer nights as well as the late evening and early morning hours of spring and autumn.

### 19. *Topography.*

The use of gas is greatly influenced by earth forms. The effect of topography is closely connected with atmospheric conditions, which it influences by altering the direction and force of air currents. Wooded and very undulating ground has a very great influence on the result of a gas shell bombardment.

Gases, being slightly heavier than air, tend to flow into gullies, draws and valleys, leaving the tops of hills free. In deep, narrow and long valleys, currents of air are usually found which carry the gas long distances.

In hilly country special attention must be paid to deviations of the lethal wind from the general air current and to the mountain winds which in clear weather set in at certain periods of the day. A drifting of the gases from higher to lower places, such as obtains with attacks with gas projectors, cannot be reckoned with, for the gas density in the air is less in bombardments than in the spraying method.

Gas may be used under intelligent direction in nearly every character of terrain. It may be most satisfactorily used in almost level, slightly undulating districts.

Targets, such as woods, may be shelled with good results when the wind has too high velocity for targets situated in open ground. When undulations in the ground are very marked, the fact that the wind is stronger on high ground than on low must be taken into account. High ground and open places must, therefore, receive a more intense concentration than those localities which are wooded or enclosed.

The effects of gas shell will be diminished in marshy ground or in an intensely shelled area, if the craters are full of water.

During gas shell bombardments in open country, particular attention must be paid to the deviation of the local wind from the general wind direction and to air currents peculiar to the combined action of mountains and valleys, which occur on certain days in bright weather. That is, you must, if possible, consider what the wind conditions are at the enemy position.

With the long range of artillery, gas may be safely sent over to the enemy no matter what the direction of the wind. It is merely necessary to establish safety zones (see paragraph 11), and knowing the characteristics of the gases available, deliver the gas where it may be needed in an effective dose, which at the same time cannot be blown back in dangerous quantities to our own line. To do this requires the ability to make use of topographic maps and judge the effect of topography on prevailing winds.

20. *The Wind Circle.* The Gas Officer cannot do good work without good topographic maps. On each map which exhibits the trench systems, he should mark the Gas Safety Zones and draw a wind circle six inches in diameter. This wind circle is divided into forty parts, called "Grads," numbered clockwise.

The daily meteorological report gives the direction of the wind by numbers. The wind blows from the circumference to the center of the circle, which represents the gun position. The 0 of the circle is north, 10 is east, 20 is south and 30 is west. In transmitting wind data, 50 is added to wind speeds to prevent confusion with the numbers which indicate wind direction. The speed is in meters per second.

The artillerymen uses the wind circle to make meteorological corrections to his firing data. The Gas Officer uses the wind circle to study the probable effect of topography on the travel of a gas cloud impelled by the prevailing wind. The wind direction should be plotted on the maps.

The Gas Officer should lay over his map each day a piece of transparent paper. On this he should trace the boundaries of the safety zone, a few of the heavier contours showing marked earth forms and also the bottom of all large depressions and the crests of all hills, indicating heights by figures. Across the hills and valleys he should draw in yellow pencil parallel lines indicating the wind direction. Mark in figures on these lines the speed in meters per second. Date each sheet and sign it.

With the data thus ready, the Gas Officer can quickly decide just what gas to use on a certain target and the quantity. These sheets should be filed for record and the one used on the day on which gas is fired should accompany the report on the firing, a copy being retained at headquarters.

In order to be able to allow for unexpected atmospheric changes, the firing order should, if necessary, be given by pre-arranged signal visible at great distance; for instance, from a captive balloon. A similar signal is also to be decided upon in case break or cessation of the bombardment is necessary. The lighter the bombardments are, the more can these measures be modified.

### TACTICAL USE OF ARTILLERY CHEMICAL SHELL.

21. Two general types of bombardment with gas shell may be carried out. Variations and combinations of these two types should be often employed. The two general types are:

(1) *Destruction Fire.* This type of bombardment is to be carried on with lethal shell, and is intended to produce casualties. Ordinarily, firing for more than two minutes at one time is not profitable, though in dead calm or thick woods and similar places, especially at night, the time may be extended to five minutes. Too much emphasis cannot be laid upon the fact that a gas attack must be executed with the greatest rapidity of fire and that the hits be close together, so as to create a solid gas cloud. Only in complete absence of wind may the rapidity of fire be decreased. In case of air currents, allowance must be made accordingly in the range finding. Gas effects at the objective must be obtained quickly. The necessary number of rounds is therefore to be distributed to as many batteries as possible.

(2) *Neutralizing Fire.* This fire is intended to lower the physical resistance, morale of the enemy, and to interfere with his activities, by causing him to wear his mask continuously, for a considerable time. This result can be obtained most economically with persistent gases—H. S.

22. A heavy fire, or a very rapid rate of fire, with a persistent gas is not necessary. Since instantaneous lethal effects are not obtainable, a heavy burst of fire at the commencement of a bombardment is not required. After the desired concentration has been reached, it is only necessary to fire a small number of shell occasionally in order that this concentration will be maintained. A sudden burst of fire with H. S. amounting to 1/10 that for phosgene may be used to begin a bombardment.

23. *Counter-Battery.* This, as a rule, should consist of a burst of destruction fire, followed by a slow, neutralizing fire with a persistent gas. The final burst of concentrated fire with a lethal gas is often useful, if the neutralizing fire has been maintained for four or more hours. This final burst of fire should last for ten or fifteen minutes. Its purpose is to penetrate the enemy masks that have been exhausted by long continued wearing.

24. *Harassing.* This is solely a neutralizing fire, for the purpose of hampering enemy movements of material, and troops, and to cause exhaustion of personnel through wearing the mask.

Lachrymatory gases are used primarily for harassing effect. Any lethal effect obtained from those gases will be purely incidental, and they should not be used for this purpose, as the amount required would be abnormal. Where lethal effect is desired after lachrymatory firing, a bombardment with lethal shell may follow immediately.

25. *Blanketing.* This is a type of neutralizing fire which may be employed under especially favorable weather conditions. During a dead calm (at night) it is possible, with a comparatively small number of shell, to form clouds of gas which will lie in pools of fog, in hollows and valleys, for a considerable time after the shelling has ceased. If no wind arises, the enemy will have to wear his mask all night, or vacate the low ground. Non-persistent, lethal gases are useful in such cases. *Caution:* The objective must be far enough away from the friendly line to avoid danger from a slight drift of the clouds or from an adverse wind springing up.

26. *Interdiction Fire.* This is a type of neutralizing fire for the purpose of rendering important positions untenable. This is best carried out by the use of mustard gas, unless our troops expect to occupy or pass over the area soon after the bombardment.

27. *Bombardment of Area.* In the bombardment of an area, which is essentially a question of neutralizing fire, it should be noted that it is often advisable to open the fire with a burst of lethal shell on certain important targets in the area, and then to carry out the slow neutralizing fire.

28. While attacking one front, a harassing and neutralizing mustard gas bombardment can be effectively made on fronts, flanks, rear areas, and strong points not thus attacked. Troop concentrations, reserves, artillery groups, lines of communication, villages, and extended areas which it is contemplated the advancing troops will not reach, may be attacked with mustard gas.

When more than one objective is to be attacked for surprise effect with a lethal gas, the objective to the leeward of the wind is to be bombarded first. In this way the surprised effect on the second objective is not lost. However, if fire on other targets are made soon enough so the wind will not carry gas to later targets before fire is opened on them this rule need not be applied.

29. When harassing fire with a tear gas is to be used upon more than one objective, the objective to the windward should be first bombarded.

When it is not considered practicable to attack a strong position by frontal assault the position may be rendered untenable for the enemy by shelling heavily with mustard gas, which will not interfere with surrounding or passing around position.

30. *Barrages.* Gas shell may be employed in a barrage, in the following ways:

(a) Accompanied by H. E., when used under favorable weather conditions, gas tends to cause confusion among the enemy. About 25% of gas shell (1 gun per battery) should be used. While no danger to our own troops will occur from the use of this small percentage of gas shell, it will serve to deceive the enemy, causing him to wear his mask, and in this way hinder his activity. With a four m.p.h. wind, men can follow within one minute.

(b) May be used in "back" barrages, during an attack, to place enemy reserves and reinforcing troops at a disadvantage, by compelling them to wear masks. This is highly destructive to morale.

31. *Formations for Counter-Attack.* After an infantry objective has been reached, a gas attack will cause casualties, confusion and delay, among enemy troops intended for use in counter-attacks.

### SMOKE.

32. *Screens.* Smoke screens have many times greatly aided in the execution of all sorts of operations, large and small, and it would seem that their use should be greatly extended. Smoke candles or grenades will always be used for the production of smoke, when their use is possible. Within the limit of their range trench mortars should be used. At greater distances artillery shell are a necessity. For all uses of smoke clouds, wind conditions must be carefully studied.

33. *Kinds of Smoke Shell.* There are two varieties of smoke shell in our service: White Phosphorous (W. P.) shell, used only for screening purposes, and titanium tetrachloride (F. M.) shell, used only for ranging purposes. The W. P. shell are not intended for ranging, but they can be used for this purpose when the F. M. shell is not available, provided certain corrections are made. (See paragraph 12). Vice versa, the F. M. shell are not intended for screening purposes, although they may be used as such, if W. P. shell are not available. The F. M. shell will not give as dense and durable a cloud of smoke or as great a screening effect as the same size W. P. shell, hence it will be necessary to increase the number of F. M. shell used and the rate of fire over the figures prescribed for establishing smoke screens with W. P. shell.

### 34. *Smoke May be Used by the Artillery:*

(1) To blind enemy observation posts, machine gun emplacements, infantry or artillery, thereby screening-in infantry raids or other operations.

(2) In order to draw fire and distract attention from another operation.

(3) To define visibly the limits of an attack or raid.

(4) As a fake gas attack, or to make the enemy think a real gas attack is more extended.

(5) In back areas to screen gun positions, etc.

(6) Occasionally for burning effect against enemy troops.

35. *Considerations Affecting the Quantities of Smoke Shell Required to Form a Screen.* The number of smoke shell required to form an effective screen depends upon the considerations enumerated under the general discussion on "Smoke Screens" (See paragraph 32). In winds much over 20 miles per hour it is practically impossible to form an opaque screen. The stronger the wind the further must be the source of the screen from the objective. Experiments have shown, however, that a screen can be formed even in a strong wind. The best wind for the use of artillery shell appears to be one having a velocity of about 14 m. p. h. (6 meters per second), and blowing across the object to be concealed.

100 yards per 10 feet per second of wind may be taken as a general guide as to the distance from the object at which artillery smoke shell should be placed. In hot weather particularly the smoke tends to rise from the ground, and there is, therefore, a greater tendency for gaps to form in the screen.

The effect of phosphorous shell of all kinds is cumulative, as the globules of phosphorous continue to burn on the ground for 15 to 20 minutes. As the cloud in the case of phosphorous projectiles is at its thickest soon after the bursts, it will be maintained more evenly by adding small quantities at frequent intervals of time rather than by adding large quantities at greater intervals.

36. *Number of Shell Required.* No definite rules can be laid down as to the exact quantities of smoke shell required to form a screen, as the conditions will vary to a very large extent. However, as a general guide it may be taken that the following number of shell are required to form an adequate smoke screen under normal conditions:

75 mm. shell, 2 rounds per 10 Yds. per Minute.

4.7 in. shell, 2 rounds per 15 Yds. per Minute.

155 mm. shell, 2 rounds per 25 Yds. per Minute.

37. The above figures apply to the establishment of the smoke screen which may thereafter be maintained by a reduced rate of fire, which should be controlled primarily by observing the behavior of the smoke screen. In general, it may be stated that one half the above rate of fire will effectively maintain a smoke screen after it is once established and under normal conditions. The following example is given for guidance:

*4.7-inch Smoke Screen.* The four guns of the battery were concentrated on a point 400 yards to the windward of the place where the commencement of the screen was required. The wind at the time was 40 ft. per second. The relation of the distance—400 yds. to the wind—40 f. p. s. is worth noting. Battery fire, 10 second intervals was used and the result was effective.

## HANDLING AND STORAGE OF GAS SHELL.

### *General.*

38. The chief source of danger in handling gas shell is leakage, which can always be detected by the smell, or by the effect produced upon the eyes. All personnel handling these shell should carry gas masks.

The handling of shell under suspicion, and the rescue of any man effected by the fumes will be the duty of special detachments which should be detailed and trained for this purpose. If a leak is suspected, it should be reported immediately and all men working in the vicinity should bring the respirator to the "alert" position.

39. *Leaking gas shell may be disposed of in two ways:*

(a) By burying them. Shell should be buried six feet deep and covered with a layer of chloride of lime before filling in the earth. They should not be fired from the gun. Spots where defective shell are buried should be indicated by sign posts driven into the ground and marked in an appropriate manner. Leaky shell can generally be detected by the smell of the gas.

(b) By exploding them.

40. If there are large numbers of leaking shell, it is more satisfactory to explode them than to bury them, thus preventing the contamination of the area from a large number of buried shell. When gas projectiles are to be blown up, they should be collected in lots so as not to exceed 100 lbs. of gas. Each lot should be exploded singly and another lot should not be exploded until the first gas cloud formed has disappeared. The gas cloud from one lot of this size is dangerous up to 500 yards' distance, and personnel within that distance to leeward should be warned. The procedure for exploding the gas projectiles is almost the same as that followed for exploding H. E. and shrapnel. The projectiles are piled in a narrow ditch about 6 feet

deep, and an explosive or blasting charge is placed in the center of the lot and connected up to the blasting loads or time fuse. The lot is then covered with sand bags or other material to keep the metal pieces from scattering. The lot is then exploded. Then when the gas cloud has fairly well cleared, men wearing the respirators will fill in the holes, first covering with a layer of chloride of lime. Men working at destroying the blind gas projectiles should always wear the respirator from the moment they start to blast. Under no conditions should leaking shell be thrown into water. The necessity of careful handling of this sort of ammunition cannot be impressed too strongly. These instructions, however, are purely precautionary and are not intended to give the impression that the handling of these shell is unduly dangerous.

### TRANSPORT OF GAS SHELL.

41. Wagons containing gas shell, on arrival at depots, will be opened by a gas N. C. O. who will supervise the unloading and storage of shell. If the presence of a leaking shell is suspected in any wagon, the matter must be reported at once to the officer in charge. Such a wagon will then be unloaded by a special detachment wearing the respirator in the alert position.

If possible, gas ammunition should be carried in trucks provided with shutters which should be left open. If closed trucks only are available, on arrival at the ammunition depot, or dump, the doors of both sides should be opened by a competent person and no one should be allowed to enter the truck until it is ascertained whether or not any gas has leaked. If, of necessity, open trucks have to be used, no tarpaulins should be put on.

### STORAGE OF GAS SHELL.

42. This ammunition should be stored in separate bays and should be ventilated as well as possible, compatible with the exclusion of rain. If stored under tarpaulins, arrangements should be made to give access of air to the stack. Gas shell should be left in a cool place, as heat increases the internal pressure and the possibility of leaks.

Buildings on or about the line between the gas area of the ammunition depot and the direction of the wind, must not be occupied during a raid. A messenger wearing a box respirator should be sent off to rouse sleeping men in such buildings and to see that the buildings are clear. If gas ammunition has been destroyed, it is forbidden to enter these buildings until they have been ventilated thoroughly, by men wearing respirators. All windows and doors of the building may be opened and wood fires burned in the center of the cellars. The building will be occupied only when declared safe by a gas officer or gas N. C. O.

Inasmuch as the proportion of leaks tends to increase with storage ammunition parks should supply batteries from the oldest lots on hand.

### GAS SHELL DUMPS AT BATTERIES.

43. At battery positions, gas shell should be piled in small dumps, the number in each being generally limited as follows:

The 75 mm.....	100
The 4.7 in.....	50
The 155 mm.....	25

Dumps should preferably be located to the leeward of battery positions, according to the prevailing wind.

If a direct hit occurs on a dump of gas shell, respirators will be put on immediately and without waiting for orders, and if possible a move will be made to the windward. All personnel of a battery will be kept constantly informed of the direction of the wind. (Flag, wind-vanes, etc.)

"Dud" gas shell, or gas shell debris, must not be touched until examined by a gas N. C. O. who will attend to the proper disposal of the same.

### SPECIAL PRECAUTIONS RELATIVE TO MUSTARD GAS SHELL.

44. Mustard gas shell which show traces of leakage should be handled only by men who are protected with respirators and special gloves. Men detailed for such work should likewise be equipped with protective clothing (if obtainable), whenever there is a possibility of the projectiles coming in contact with the clothes.

As soon as the shell are received, they should be examined. Any indication of leakage at the gaine joint is a danger sign. (Masks and gloves should be worn.)

Whenever possible, cases containing the shell should be stored in small piles in the open air.

Near all such piles, a heap of earth and a supply of chloride of lime should be provided for covering any shell that may be burst by enemy fire. All storage depots should be supplied with shovels, and with chloride of lime in air-tight containers.

If an ammunition dump is reached by enemy fire, all personnel should move off to the windward and all men within 200 meters to the leeward should be warned. Broken shell should be covered with a layer of chloride of lime on top of which 6 inches of earth should be spread. During this work, masks and protective gloves should be worn.

Undamaged shell of a small dump struck by a direct hit will not be set apart for future use, but will be buried with the fragments of the damaged shell in a hole six feet deep and covered with a layer of chloride of lime before filling in.

## CHEMICAL ARTILLERY AMMUNITION.

45. The following is a brief description of the chemical ammunition which may be used by our troops. It includes not only chemical shell of American manufacture but also French shell which may be used by our troops. It does not include a discussion of artillery ammunition in general which has been fully covered in "Notes on Artillery Ammunition", issued by the Office of the Chief Ordnance Officer, A. E. F.

In our service, chemical shell include the following classes:

Gas.  
Smoke.  
Incendiary.

## GAS SHELL.

46. A description of the gases which have been approved for use in our artillery shell is given hereinafter. A thorough knowledge of the gases, their properties and effects, is necessary. Gases may be divided into three classes, as follows:

Non-Persistent.  
Semi-Persistent.  
Persistent.

47. The following table shows our gases, divided according to this classification, and their principal characteristics:

CLASS	NAME OF GAS IN ORDER OF PERSISTENCY	BOILING POINT	PSYCHOLOGICAL ACTION
1 Non-Persistent.. . . .	D.A.) C.G.)	— + 8° C.	Lethal and Sternutatory
2 Semi-Persistent.....	P.G.) xx N.C.) x P.S.)	— + 112° C.	Penetrative and Suffocant
3 Persistent.....	C.A.) H.S.)	— + 217° C.	Lachrymatory and Vesicant

x. N. C. is a mixture of 80% P. S. and 20% K. J. The active principle of this mixture is P. S.; the K. J. acting merely to stabilize the P. S. and help penetrate the mask.

xx. F.G. is a mixture of 75% P. S. and 25% C. G. As with N. C. the active ingredient is P. S.—the purpose of the C. G. being to stabilize the P. S. and to add to its toxicity.

*Non-Persistent Gases.*

48. It will be noted that the only non-persistent gas which we are using, (C. G.)\* is lethal and boils at +8°C. (46°F.). In general, the non-persistent gases all have these same charac-

\* (D. A. is not a true gas. It is a solid substance and its action is very different from that of the liquids. Upon the bursting of the shell the D. A. is expelled from that of a highly pulverized cloud of dust. These fine particles remain in suspension in the air and the particles pass through the mask.)

teristics. They are all lethal and boil below  $+20^{\circ}\text{C}$ . ( $68^{\circ}\text{F}$ .), i. e., below normal atmospheric summer temperature. For this reason these gases change from liquids to gases without the aid of any artificial agency. When the shell is burst the liquid at once gasifies. Hence, the smallest bursting charge that will effectively open the shell is used. However, the bursting charge must be of sufficient strength not only to burst the shell, but also to check, to a large extent, the forward velocity of the base portion of the shell. Otherwise a considerable portion of the liquid will be cupped in the base portion of the shell and buried in the ground or carried by ricochet beyond the point of burst.

In the employment of lethal gases, the main object is to produce a cloud of the highest possible initial concentration which will drift down wind and completely envelop the object attacked. Such a cloud should consist of a highly concentrated nucleus when liberated from the shell. This will drift down wind and expand by lateral rather than upward enlargement. The formation of such a cloud requires: First, complete vaporization at the moment of liberation; and Second, a bursting charge which will completely shatter the shell, but which is not so strong as to give undue dissipation of the liquid contents, particularly in an upward direction.

It is essential that the bursting charge should break the shell completely into small fragments. The more rapid and complete the break-up, the more concentrated is the cloud. Moreover, the loss of heat due to the sudden vaporization adds density to the cloud nucleus formed.

#### *Semi-Persistent Gases.*

49. The semi-persistent gases boil between  $+20^{\circ}\text{C}$ . and  $+200^{\circ}\text{C}$ ., i. e., above normal atmospheric temperature. With these gases to obtain a cloud nucleus of greatest possible concentration it is necessary to expel the liquid contents in a high state of atomization. This results in the most rapid vaporization with the least possible disturbance of the cloud. To secure this effect, the bursting charge should be of high power to insure maximum atomization, and yet not so high as to destroy the gas by dissociation. The object is to ensure that the liquid is converted into a cloud with least possible disturbance. This requires a more powerful bursting charge than the non-persistent gases and a shell of greater resistance, so that the liquid may be released under maximum pressure.

#### *Persistent Gases.*

50. In the case of persistent gases, boiling above  $+200^{\circ}\text{C}$ ., the object sought is quite different. Here, the cloud should be reduced to the minimum, and the area sprayed by the liquid contents of the shell increased to a maximum. This requires a

large bursting charge of relatively high capacity but of slower action than the charge for the semi-persistent gases, and at the same time, a shell of relatively less strength than that required for complete atomization, but of sufficient resistance to give the maximum amount of coarse spray that will reach the ground as such. The charge which sprays the greatest area of ground and gives the minimum cloud is the one of maximum effectiveness. Due to their high boiling points, the persistent gases are relatively slow in their action, and hence prompt effects cannot be obtained unless the vaporization of the gas is secured by some artificial means. Such a means is a bursting charge developing high temperature and pressure, both of these conditions accelerating vaporization, the temperature acting directly and the pressure through increased pulverization. Consequently, if it is desired to obtain quick effect from persistent gases such as H. S., the shell should be loaded with a super-charge of high explosive, but it must be remembered that by so doing the gain in activity of the gas is obtained at the expense of greatly reducing its persistency. Another advantage in providing H. S. shell with a super-charge of high explosive is that they detonate with the noise and the shock of a true H. E. shell and thus disguise the fact that they are gas shell. Recent developments in the use of H. S. have indicated that a portion, at least, of these shell should be provided with a super-charge of high explosive to accelerate their action. If H. S. shell having a super-charge of high explosive are used they will be stencilled with some distinguishing mark to indicate the fact that the bursting charge is above normal.

### CONSTRUCTION OF GAS SHELL.

51. In general gas shell are similar to high explosive shell. In fact, the majority of gas shell in use at the present time are converted H. E. shell. While the principles involved in the design of gas shell are radically different from those affecting H. E. shell, it has been considered desirable to simplify the manufacturing program by converting H. E. shell into gas shell. As the proportion of gas shell to H. E. shell increases, it becomes more and more important for gas shell to be specially designed.

52. Gas shell consist of the shell body, which contains the gas, the gaine tube (adapter and booster casing), which screws into the nose of the shell and contains the bursting charge; and the bursting charge which consists of a small quantity of high explosive sufficient to open the shell, and, in some cases, to atomize the liquid contents. Since most of the gases used enter the shell, as liquids, they expand as liquids when heated, and it is, therefore, necessary to leave a space for this expansion and only partially fill the shell. The void amounts to from 6% to 11% of the total capacity of the shell; depending

upon the coefficient of expansion and the vapor pressure of the gas and the pressure which the joint between the shell and gaine tube will withstand.

53. There are various methods of making these joints gas tight:

(a) The general method employed by the British to prevent leakage of gas into the gaine tube, is to make the adapter and gaine tube of one piece, so that there is no joint through which gas may leak into the gaine tube. To prevent the gas from leaking through the joint between the adapter and the shell body, the British paint the threads with cement, screw the adapter in, and then "spin" over the exterior of the joint between the adapter and shell. This joint is made before the shell is filled and a test pressure of 100 lbs. per square inch is applied to the shell, through the filling hole in the side of the shell to test the integrity of the joint. The shell is then filled and the filling hole plugged up with a small tapered iron plug.

(b) The French use, in some cases, a one-piece adapter and gaine tube. In other cases, however, the gaine tube is threaded into the adapter. The following is quoted from a French document and shows the method of closing joint between the adapter and shell body:

"To close this, we put in the first place between the bottom part of the head of the gaine and the machined shell, around the eye of the projectile, a pliable ring of lead tubing with a core of asbestos; in seating the gaine into the eye of the projectile, this ring is compressed and forms a dam between the head of the gaine and the throat of the eye of the shell. Furthermore, the threads are painted with a cement which is not attacked by the charging liquid and which in addition to stopping leakage adds to the solidity of the union of the two parts....."

(c) In our present American models of gas shell the gaine tube is welded to the adapter, though it is probable that, for certain gases at least, this method will be abandoned for a one-piece adapter and gaine tube. The joint between the adapter and the shell body is made gas tight by means of a tapered or pipe thread. The adapter and gaine tube are screwed into the shell until the tapered threads bind tightly and produce a gas tight joint. To facilitate assembling, the threads on the adapter are lubricated with oil, but no cement is used; dependence for gas tightness is placed entirely upon the metal to metal contact between the threads.

54. Of the three methods mentioned above, that employed by the British is probably the most satisfactory, and the method of side filling has the additional advantage of permitting the testing of the joint before filling.

55. For certain gases, notably those containing bromine compounds, which have a corrosive action upon steel, it is necessary that the shell have a lining of glass or lead; and the gaine tube, a coating of enamel; in order to protect the metal from the action of the gas.

#### TYPES OF AMERICAN SHELL.

56. It is intended to provide American chemical artillery shell in the following calibers:

75 mm. Gun  
4.7" Gun  
155 mm. Gun  
155 mm. How.  
5" S. C. Gun  
6" S. C. Gun  
8" S. C. Gun  
8" How.  
9.2" How.  
240 mm. How.

#### MARKINGS FOR AMERICAN SHELL.

57. American chemical artillery shell will be marked with colored bands to denote the different types of gases, as follows, (See Appendix, Fig. 3):

U. S. Symbol	U. S. Markings $\frac{1}{2}$ " Bands around Shell as Follows	U.S. Symbol	U. S. Markings $\frac{1}{2}$ " Bands around Shell as Follows
D.A.	1 White	B.A.	1 Red
C.G.	2 White	C.A.	2 Red
P.G.	1 White, 1 Red, 1 White	H.S.	3 Red
P.S.	1 White, 1 Red	W.P.	1 Yellow
N.C.	1 White, 1 Red, 1 Yellow	F.M.	2 Yellow

*Red Bands* denote persistency.

*White Bands* denote non-persistency and lethal action.

*Yellow Bands* denote smoke.

*Purple Bands* denote incendiary.

The number of bands indicates the relative strength of the property indicated. Thus, three red bands denote a gas more persistent than one red band, and three white bands indicate a gas where lethal action is greater than one marked with only one white band.

The body of the shell is painted gray. The words "Special Gas" or "Special Smoke," as the case may be, are stenciled lengthwise of the shell in black block letters  $\frac{5}{8}$ " high.

Incendiary shell are painted gray, with the word "Special Incendiary" stencilled lengthwise in black block letters  $\frac{5}{8}$ " high, but with no distinguishing bands.

## AMERICAN SHELL FILLING

The following are the amounts of each kind of chemical filling contained in the different calibers.

Time	Calibers	Mark	Approximate weight of projectile less fuse and the filling in pounds	The Approximate Weight of Shell Filling								Smoke	
				Gas								F.M.	W.P.
				H.S.	C.G.	N.C.	P.S.	C.A.	B.A.	Lbs.	Lbs.		
				Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Field													
Gun. ....	75 mm.	II	10.27	1.35	1.32	1.74	.....	1.45	1.97	.....	1.71	1.90	
Gun. ....	4.7"	II	37.40	4.88	4.27	5.82	5.30	4.44	6.36	.....	5.53	6.14	
How. ....	155 mm.	II	80.80	11.80	11.00	14.50	13.66	12.18	16.41	.....	14.30	15.85	
Gun. ....	155 mm.	VII	79.45	11.30	11.00	14.50	13.66	12.18	16.41	.....	14.30	15.85	
Gun. ....	5"	VI	42.84	5.38	.....	.....	.....	.....	.....	.....	6.70	.....	
Gun. ....	6"	III	74.98	10.50	.....	.....	.....	.....	.....	.....	13.28	.....	
How. ....	8"	III	169.75	22.45	22.01	28.90	27.20	24.20	32.67	.....	28.40	31.50	
Gun. ....	8"	III	169.75	22.45	.....	.....	.....	.....	.....	.....	28.40	.....	
How. ....	9.2	*	252.65	29.45	28.69	37.80	35.62	31.70	42.78	.....	37.20	41.30	
How. ....	240 mm.	*	303.50	37.50	36.54	48.20	45.37	40.40	54.48	.....	47.40	52.6	

\* These volumes are based on the H.E. shell.

Note.—Of the fillings given in the above table it should be noted: N.C. is the same as P.S. except that it contains a stabilizer (K.J.), B.A. and C.A. shell are both lachrymatory and can be used interchangeably, except that C.A. is several times more effective than B.A.

F.M. and W.P. shell are both smoke shell. F.M. is a liquid, and F.M. shell are therefore primarily intended for ranging gas shell. W.P. is a solid and produces a dense and more persistent smoke than F.M., hence W.P. shell should be used primarily for smoke barrages and screens.

With fixed ammunition (75 mm. and 4.7"), chemical shell are also marked on the base of the cartridge case by a black band  $\frac{3}{8}$ " wide and the words "Special Gas," "Special Smoke," or "Incendiary," in  $\frac{1}{4}$ " letters.









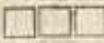

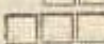
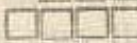
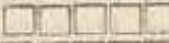
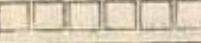


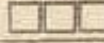
The boxes in which chemical shell are packed are marked on each end with distinguishing bands and words used on the shell in addition to markings common to all artillery shell.

#### WEIGHTS OF AMERICAN CHEMICAL SHELL.

58. For the present, the system of weighing and marking of chemical shell will follow the general scheme employed with H.E. artillery shell, i.e., each caliber of shell will be divided into a number of different weight lots and marked on the 75 mm. by crosses just above the rotating band, on the 4.7" by squares just below the bourelet, and for calibers larger than 4.7", by squares on the ogive. In addition, for calibers greater than 4.7" the mean weight of the lot will be stencilled on the shell, on 6" shell just above the driving band and on other calibers on the ogive.

This system will probably be changed so that chemical shell will be of one weight only for each caliber.

59. The method of indicating the weight lots under the present system is shown in the following table:

Caliber	From		To		Weight Marks	Weight Stencil
	Lbs.	Oz.	Lbs.	Oz.		
75 mm.	10	11	11	0	L	
	11	0	11	5	+	
	11	5	11	11	++	
	11	11	12	0	+++	
	12	0	12	5	++++	
4.7" Shell	43	0	43	11		
	43	11	44	6		
	44	5	45	1		
5 inch.	49	11	50	9		50.10
	50	8	51	5		50.90
	51	5	52	2		51.70
6 inch.	86	14	88	4		87.58
	88	4	89	10		88.94
	89	10	91	1		90.34
155 mm.	91	3	92	5		41 K 700
	92	5	93	6		42 K 200
	93	6	94	8		42 K 700
	94	8	95	10		43 K 200
	95	10	96	12		43 K 700
8 inch.	192	1	195	6		194.58
	195	6	198	11		197.88
	198	11	202	0		201.20

### FRENCH CHEMICAL SHELL

60. The only French chemical shell to be used by our service are the 75 mm. gun, the 155 mm. gun and howitzer, and the 240 mm. howitzer. The 240 mm. howitzer gas shell is still in process of development.

### WEIGHTS OF FRENCH CHEMICAL SHELL.

61. The general weight classification of the 75 mm. and 155 mm. shell is the same as the U. S. classification.

### MAKING OF FRENCH CHEMICAL SHELL.

62. The system of marking and the weight, nature, and action of the filling of the French chemical shell which may come into the hands of our troops are shown under description of shell. Mixtures No. 4 and 4B are not authorized for use in our service.

### SMOKE SHELL.

63. In addition to the use of smoke shell for smoke barrages, these shell will be used in our service for ranging gas shell.

Gas shell of the French, British, and Germans all have visible bursts, due to the presence of a smoke producing mixture in the shell. The French mix a "fumigène", or smoke producing compound, with the chemical filling. The British incorporate the smoke producing material with the bursting charge. The Germans produce a visible burst by use of a very large bursting charge. All of these methods reduce the efficiency of the shell and also have the disadvantage of producing a visible gas cloud whose limits are readily discernable by the enemy.

All smoke producing compounds will be omitted from American gas shell and the bursts will, therefore, be practically invisible. For ranging, therefore, it is necessary to have smoke shell of the same weight and ballistic characteristics as the gas shell. Smoke shell will first be fired until the correct range has been ascertained, and then the fire for effect will be continued with gas shell having invisible bursts.

64. By far the best smoke producing material for smoke barrages and curtains is white phosphorous, and this is used in all smoke shell intended for barrage purposes. These shell are known as W. P. shell and are marked with one yellow band. However, since phosphorous is a solid material, the W. P. shell is not accurate for ranging purposes, since shell filled with liquids (as all our gas shells are) have different ballistic characteristics and therefore different ranges from solid filled shell. For this reason it is necessary that smoke shell for ranging purposes be liquid filled. The best liquid smoke producing material is F. M. which has been adopted for our smoke ranging shell.

65. While the W. P. shell is not intended for ranging, it can be used for this purpose when the F. M. shell are unavailable, provided certain range corrections are made. The F. M. shell is not intended for barrage purposes although it may be so used, if W. P. shell are not available. The F. M. shell will not give as dense and durable a cloud of smoke or as great a screening effect as the same size W. P. shell, hence it is necessary to increase the number of shell used and the rate of fire, over the figures prescribed for smoke screens with W. P. shell. The exact amount of shell and rate of fire can best be determined by observation of the smoke screen during its establishment and maintenance.

TABLE OF FRENCH SPECIAL PROJECTILES.

SHELL	PROPERTIES	CHARGE	FILLING	PRIMER	MARKINGS	NOTES	EFFICIENCY
75 mm. No. 2.	Incendiary.	Carbon disulphide White Phosphorous Cyl. of incendiary in celluloid.	320 cc.	Gainé Model 1897-1914. Soldered joint. Percussion fuse 24/31-14.	Green Ogive. Red body. No. 2 on top of ogive and also on bottom.	Body of shell explosive.	
75 mm. No. 3.	Incendiary.	White Phosphorous Neutral Liquid.	485 grs. 240 cc.	Gainé Model 1897-1914. Soldered joint. Percussion fuse 24/31-14.	Green Ogive. Red body. No. 3 on top and bottom.	Body of shell explosive.	
75 mm. No. 4.	Toxic.	Vincennite Quarter-naire (V4)	478 grs.	Gainé Model 1897-1914. Soldered joint. Percussion fuse 24/31-14.	Green. 2 white rings. No. 4 on top and bottom.	Explosive fuse hole fitted with washer of plastic metal.	Immediately after formation explosion cloud is fatal but dilution quickly decreases its efficiency.
75 mm. No. 4B.	Violent Poison.	Vitrite. Magnésite Marquette	1 7.645 3 grs.	1897-1914 Mdl. Relay gainé 24/31 percussion '14 Mdl.	2 White Bands. «1B» on ogive, base and shell case.		Immediately after formation explosion cloud is fatal; under certain conditions it may have a latent action.
75 mm. No. 5.	Toxic.	Collongite, 2/3 Opacite, 1/3	714 grs.	Gainé Model 1907-1914. Soldered joints. Percussion fuse 24/31, '14 Mdl.	Green. 1 White Ring. No. 5 on top and bottom.	Explosive fuse hole fitted with washer of plastic metal.	Immediate or delayed fatal according to concentration.
75 mm. No. 7.	Lachrymatory, Toxic.	Aquinite, 3/4 Opacite, 1/4	792 grs.	Gainé Model 1907-1914. Soldered joints. Percussion fuse 24/31, '14 Mdl.	Green. 1 Orange-yellow ring. No. 7 on top and bottom.	In preparation.	6 hours.
75 mm. No. 9.	Lachrymatory, Toxic.	Martonite Opacite	507 grs. 99 grs.	Gainé Model 1907-1914. Soldered joints. Percussion fuse 24/31, '14 Mdl.	Green. 1 Orange-yellow ring. No. 9 on top and bottom.	In preparation	2 days.
75 mm. No. 20.	Vesicant. Toxic.	Xperite with T. Solvent. C. Solvent.	590 grams. or 558 grams.	1897-'14 Mdl. Relay Gainé - 24/31. Per. Fuse. '14 Mdl.	2 Orange Yellow Bands. «20».		15 days

75 mm. No. 21.	Very violent lachrymatory. Irritates upper respiratory tracts.	Camite, 13. Aquinite, 100.	685 grs.	Enam- elled Gaine without extension '14 Model 24/31. 1. Percus- sion Fuse.	1 Orange Yellow Band, '21a.	15 days
155 mm. F. A. No. 4.	Toxic.	Vincennite. Quaternaire.	2 Kgs. 850	Gaine 40, Cartridge 147 mm. Wedging ring 24/30 Percus- sion fuse. 24/31 1A.	Green Body. 2 White Rings. No. 4 on top of ogive.	Immediately after formation, explosion is fatal, but dilu- tion quickly de- crease its efficiency.
155 mm. F. A. No. 5.	Toxic.	Collongite, 2/3. Opacite, 1/3.	4 Kgs. 300	Gaine 40, Cartridge 147 mm. Wedging ring 24/31 Percus- sion fuse. 24/31 1A.	Green body, 1 white ring. No. 5 on top ogive.	Same as 75 mm. above.
155 mm. F. A. No. 7.	Lachrymatory Toxic.	Aquinite, 3/4. Opacite, 1/4.		Gaine 40, Cartridge 147 mm. Wedge ring 24/31, Per. fuse 24/31 1A.	Green body, 1 white ring. No. 7, on top of the ogive.	6 hours.
155 mm. F. A. No. 20.	Vesicant Toxic.	Yperite with T. or (solvent C.)	3420 grs 3420 grs	1897-1914 Mdl. Re- lay gaine 24 / 31 percussion fuse. 1914 Model.	2 Orange Yellow bands. '20a on top of ogive.	15 days.
155 mm. F. A. No. 21.	Lachrymatory Irritates upper respiratory tracts.	Camite, 13. Aquinite, 100.	3075 grs.	1895 Model Cyl. 40-gaine but with- out extension for smoke product. Primed as the No. 4.	1 Orange Yellow Band, '21a on top of the ogive.	15 days.
155 mm. F. A. Type Naud.	Incendiary.	Carbon disul- phide and Tar. Phosphorous 1 Kg. Cyl. of Incendiary matter.	660 cc. 650 cc. 67 cc.	Gaine system; fuse 22/31 1.	Green body, Red Head, and black ring.	Provisional Charge.
155 mm. (Steel) Type Naud.	Incendiary.	Carbon disul- phide and Tar. White Phos- phorous. Cyl. of Incendiary.	1520 cc. 3 Kgs. 800. 3 Kgs. 160.	Gaine 40, Wedge Ring and fuse 24/ 31 1. or 1. A.		

66. While the above remarks concerning the presence of smoke producing substances in our own and French and British gas shell are generally true, there are exceptions as follows:

(1) The French gas shell No. 20 (Yperite or H.S.) marked with two orange-yellow bands and No. 21 (Camite or C. A.) marked with one orange-yellow band, contain no fumigen, and hence some smoke producing shell must be used for ranging.

(2) In American shell N. C. (1 white, 1 red and 1 yellow band) has 20% K. J. in it to stabilize the P. S. K. J. is a smoke producer. Therefore, N. C. shell give a visible cloud on burst and require no ranging shell. In fact N. C. shell can themselves be used as ranging shell.

67. In the case of the French 75 mm. No. 20 and No. 21 shell, their practice is to pack one No. 5 shell (C.G. + K.J.) with 8 No. 20 or No. 21 shell, in a box which holds 9 shell. The No. 5 shell, so used, is marked on the body of the shell with a red star and on the shell case with a green star and is employed as a ranging shell for the No. 20 and No. 21 shell.

In the larger caliber French shell, the box containing only one or two shell, no attempt is made to pack smoke containing shell with the gas shell, but efforts are made to forward with every nine boxes of gas shell a box of smoke shell, so that constant ratio of the two will be maintained in supply.

At the present time our 75 mm. gas shell are being assembled in France, and since no smoke shell have arrived from the States, and our boxes also hold 9 shell, we have followed French practice; and our gas shell will be packed 8 in a box with one N. C. shell to be used for ranging the other gas shell. The box will be marked around its middle with the characteristic color stripes of the gas shell contained therein. The N. C. shell to be used for ranging, can be distinguished by its characteristic bands (1 white, 1 red, 1 yellow). In this connection, it should be pointed out that the ratio of 1 smoke-containing shell to 8 gas shell is much higher than necessary for purely ranging purposes. It is probable that 5% smoke shell will prove sufficient for registration and to maintain fire direction and control, so that there will, sooner or later, be an accumulation of N. C. shell at each battery firing gas shell. N. C. shell so accumulated should be fired by themselves for effect under circumstances and conditions prescribed for this gas.

68. When used for ranging other gas shell, no more N. C. shell should be fired than is absolutely necessary to effect registration and to maintain fire direction and control, for the reason that continued firing of smoke-containing shell results in the building up of visible toxic cloud which the enemy may avoid by withdrawal beyond its limits. Furthermore, the surprise element is largely lost by the visible burst of smoke-con-

taining gas shell. The use of large quantities of ranging shell (either F. M., W. P., or N. C.) during a gas shoot will largely neutralize the advantages of our gas shell.

69. American 4.7" gas shell are packed two in a box. No smoke shell will be packed with the gas shell of this caliber. Instead, a box of 2 smoke shell will be forwarded with every 9 boxes of gas shell. This box will be marked with characteristic color stripes of the smoke-producing shell.

Our larger caliber gas shell come packed one in a box and the same scheme as for the 4.7" will apply to these calibers.

Battery commanders should, from time to time, verify the fact that there are always on hand sufficient smoke-containing shell to amount to at least 5% of the gas shell on hand.

### INCENDIARY SHELL.

70. No satisfactory American incendiary shell has been developed as yet. The French have three calibers of incendiary shell—75 mm., 120 mm. and 155 mm. These are made from common H. E. shell by replacing a part of the explosive charge by a number of special incendiary cylinders, known as Incendiary Cylinder Ml. 1878. The Incendiary Cylinder Ml. 1878 consists primarily of a bundle of slow action quick match, tied with nitrated string, and internally and externally primed with a small quantity of ordinary quick match. This bundle is enclosed in a rectangle of cretonne cloth coated with an incendiary composition, and securely fastened with a heat-treated brass wire. The weight of the cylinder proper is 30 gr. and reaches 45 gr. when enclosed in a tar paper covering. On explosion of the projectile, the cylinder is ignited at both ends and projects 10 to 15 cm. fire jets for a period of 10 to 20 seconds, at the expiration of which time it burns, torch-like, for 70 to 80 seconds. Total combustion of the cylinder is, therefore, completed in approximately one and a half minutes. (See Fig. 4.)

### FUSES.

71. The action of all percussion fuses is started by the flash produced by the contact of a firing pin with a special detonator called a primer. This primer is filled with a very sensitive mixture of fulminate of mercury and other ingredients. The construction of all percussion fuses is such that the primer and the firing pin cannot come in contact until the shell is fired, and they are then kept a small distance apart until the shell or fuse touches the ground. Then the firing pin and the primer are brought in contact in one of the following ways:

(a) The firing pin may be attached to a movable plunger at the front end of the fuse and be forced back into the fuse the instant the plunger comes in contact with the ground. This will cause the firing pin to hit the primer which is attached to the fuse body.

(b) The primer may be carried in a movable part inside the fuse. When the shell is checked by striking the ground the inertia of this movable part carries it forward causing the primer to hit the firing pin.

It is evident that the action described in (a) will bring the needle in contact with the primer as soon as the resistance of the ground is sufficient to overcome the inertia of the plunger and force it into the fuse. It is, therefore, a quicker action than described in (b) which will take place only when the inertia of the shell itself has been overcome by the resistance of the ground.

72. Fuses having the action described in (a) are called "super-quick." Only such fuses are suitable for chemical shell.

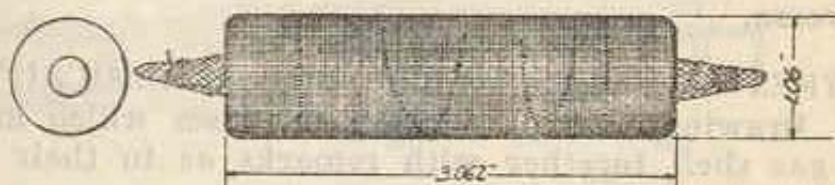
It is essential that a chemical shell should burst above ground. A fuse whose action is not super-quick allows the shell either to bury itself, at least partially, or to ricochet before bursting. If the shell is even partially buried before bursting the effectiveness of a part of the contents of the shell is lost due to its soaking into the ground. If the shell ricochets before bursting, the gas may be carried beyond the target.

73. Even with super-quick fuses, a certain amount of the effectiveness of the chemical shell is lost owing to the fact that the shell bursts at the ogive which leaves the base and part of the body more or less unbroken, and acts as a carrier for a certain portion of the liquid gases. If the angle of fall is low, the unbroken portion of the shell may ricochet and carry a portion of the gas past the target. If the angle of fall is great the unbroken portion will penetrate into the ground, thereby sealing its open end and preventing the liquid therein from being liberated.

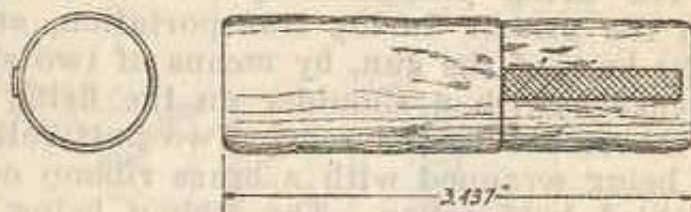
74. In order that a super-quick fuse may function, it must land on its point. If the angle of fall is small the ogive of the shell will hit the ground first, the shell may then ricochet before the point of the fuse can come in contact with the ground, and the fuse will not function. For this reason, and for the reasons given in the preceding paragraph, chemical shell should be fired with reduced charges whenever possible. This should not, however, be carried to the extreme of using vertical fire, as by so doing the dispersion is greatly increased and the unbroken base and body of the shell will bury part of the contents as explained in the preceding paragraph.

75. Owing the failure of super-quick fuses to function at low angles, and the increase in dispersion and decrease in range (caused by the great length of such fuses) when used with small calibers of shell, the French use short fuses, which are not super-quick, in the 75 mm. It is a question whether the increase in dispersion is more desirable than the loss of effectiveness due to the comparatively slow action of the short fuses.

FIG. 4



CYLINDER PROPER



CYLINDER ENCASED IN TAR PAPER

## FRENCH INCENDIARY CYLINDER MODEL 1878

OFFENSE DIVISION, ENG. SEC. C.W.S. 5540

76. For smoke shell, when used for smoke barrages, and for gases such as H. S., it is sometimes highly desirable to have time fuses, allowing air bursts. With smoke shell air bursts permit the adjustment of the dimensions of the smoke cloud and thus greatly facilitate the establishment and control of effective smoke curtains. With vesicant gases, air bursts allow a greater and more efficient dispersion of the liquid contents. A combination fuse, combining a time element and a super-quick percussion element is now being developed, so as to enable batteries to conduct gas or smoke shoots with both ground and air burst. An effective combination fuse will also greatly reduce the number of duds, since its double action will cause the shell to explode on contact if it fails on time and vice versa.

#### TYPES OF FUSES TO USE WITH CHEMICAL SHELL.

77. Drawings and descriptions of fuses which may be used with gas shell together with remarks as to their advantages and disadvantages follows:

#### FRENCH I. A. MODEL 1915, I. A. L. MODEL 1916 AND U. S. MARK III FUSES.

(Fig. 5).

78. The general functioning and construction of these three fuses are similar, the I. A. L. and the Mark III being successive modifications of the I. A. All are super-quick fuses, functioning by means of a plunger in the front of the fuse being driven into contact with a fulminate of mercury primer.

Arming.—The firing plunger is prevented from coming in contact with the primer during transportation, and while the shell is in the bore of the gun, by means of two steel half collars which engage with a shoulder on the firing plunger and prevent its movement to the rear. Two half collars are held in place by being wrapped with a brass ribbon on the end of which is a third half collar. The ribbon being wound in a direction opposite to the rotation of the gun, tends to tighten as long as there is rotational acceleration. When rotational acceleration is over, centrifugal force throws the third half collar out, and unwinds the ribbon, releasing the inner half collars and freeing the firing plunger. The firing plunger is prevented from being forced to the rear during flight by a shear wire.

Firing.—On impact the end of the plunger hits first and is driven into the body, shearing the shear pin, and impinging on the primer before the shell itself has touched the ground.

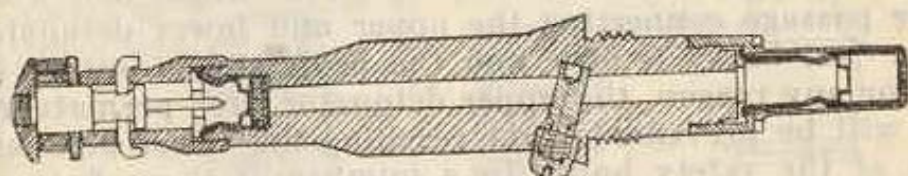
#### 79. I. A. (*Instantaneous elongated*). Model 1915.

In this fuse the lower detonator is made of compressed melinite and is connected to the upper detonator by a length of detonating fuse.

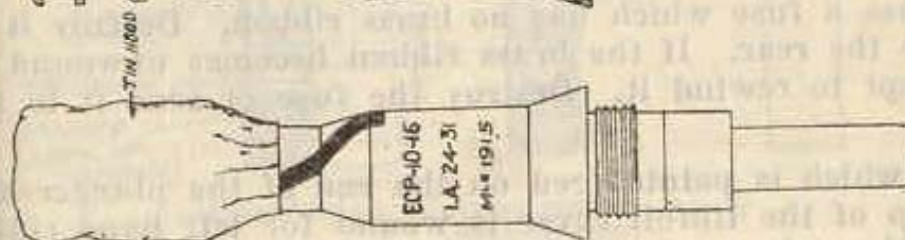
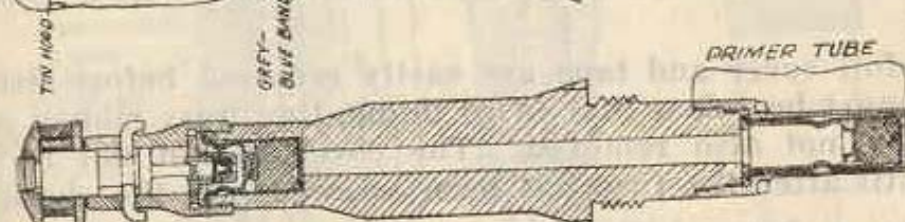
Fig. 5



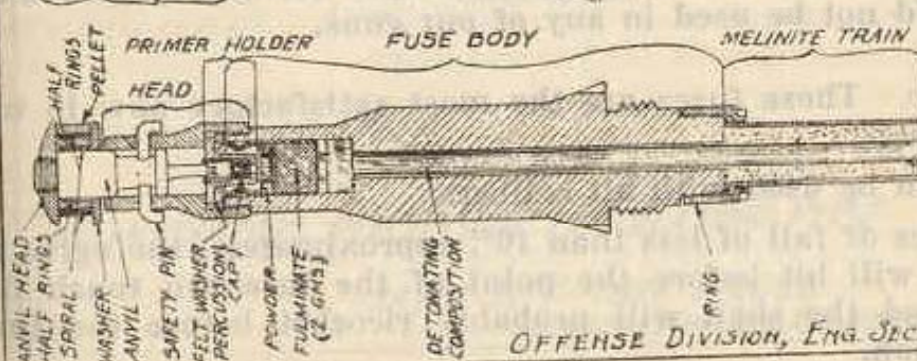
MARK III



I. A. L. MODEL 1916



LA MODEL 1915



OFFENSE DIVISION, ENG. SEC. C.W. 5530

80. *I. A. L. (Instantaneous Elongated Lefevre). Model 1916.*

This fuse is the same as the I. A. with the exception that the lower detonator is of fulminate and there is an empty flash tube between it and the upper detonator. To readily distinguish it from the I. A., the I. A. L. is painted blue around the body just below the tinfoil cover.

81. *U. S. Mark III.*

This fuse is identical with the I. A. L.

A number, however, as shown in the illustration, will have a safety device added. This consists of a centrifugal bolt which blocks the passage connecting the upper and lower detonators until after "set back" is over and the projectile is out of the gun. If, for any reason, the upper detonator fires prematurely, the flash will be prevented from reaching the lower detonator by means of the safety bolt. In a number of these fuses, as shown in the drawing, the firing plunger impinges directly on the upper denotator, thus doing away with the intermediate primer.

**Safety.**—The arming mechanism of these fuses is held in place by means of a gummed tape of oil cloth and a tinfoil cover.

The tinfoil cover and tape are easily removed before firing, but care must be taken that in so doing, the brass ribbon and weights are not also removed. The cover should not be removed until after the fuse has been screwed into the shell.

Never use a fuse which has no brass ribbon. Destroy it or send it to the rear. If the brass ribbon becomes unwound do not attempt to rewind it. Destroy the fuse or send it to the rear.

A fuse which is painted red on the end of the plunger and on the top of the tinfoil cover is wound for left hand rifling and should not be used in any of our guns.

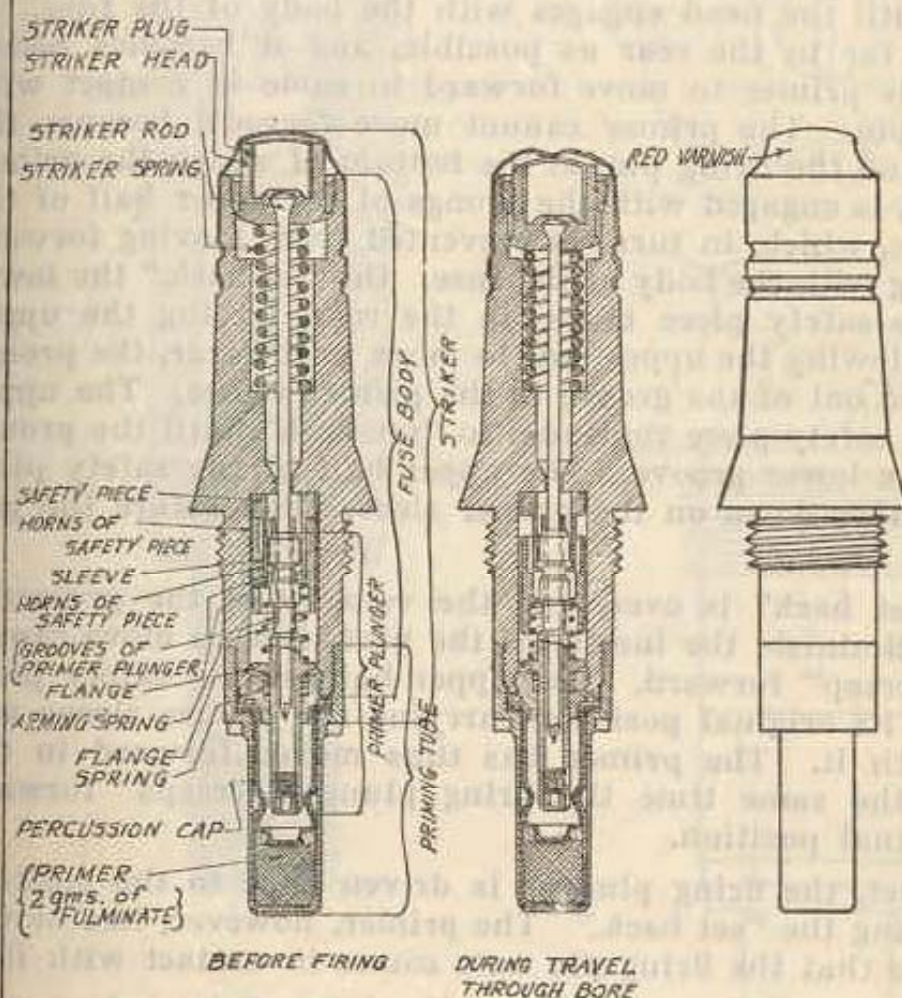
82. *Use.* These fuses are the most satisfactory now in use for gas shell.

They can be used with all calibers.

At angles of fall of less than  $10^{\circ}$ , approximately, the ogive of the shell will hit before the point of the fuse can touch the ground, and the shell will probably ricochet before the fuse can function.

With 75 mm. shell the dispersion when using fuses is considerably greater than with short fuses.

FIG. 6



## INSTANTANEOUS PERCUSSION DETONATING FUSE

24/31 R Y 1917 MODEL

OFFENCE DIVISION, ENG. SEC. C.W.S. 5536

## FRENCH R. Y. MODEL 1917 FUSES.

(Fig. 6.)

83. This is a super-quick fuse and the following advantages are claimed for it over the I. A. L.: (1) It is safe, and (2) its shape is such as to produce better ballistic effects, and, therefore, less dispersion.

Action.—The firing pin and primer cannot come in contact until both have moved. On "set back," the plunger moves to the rear until the head engages with the body of the fuse. It is then as far to the rear as possible, and it becomes necessary for the primer to move forward to come in contact with the firing pin. The primer cannot move forward because the sleeve around the firing pin, at the bottom of which the primer is fastened, is engaged with the prongs of the upper half of the safety piece, which, in turn, is prevented from moving forward by engaging with the body of the fuse. On "set back," the lower half of the safety piece moves to the rear, freeing the upper half and allowing the upper half to move to the rear, the prongs being forced out of the groove in the primer sleeve. The upper half of the safety piece continues to "set back" until the prongs catch in the lower groove. The upper half of the safety piece is thus farther down on the primer sleeve than before the gun was fired.

After "set back" is over, and the velocity of the projectile begins to diminish, the inertia of the parts free to move causes them to "creep" forward. The upper half of the safety piece returns to its original position, carrying the primer sleeve and primer with it. The primer has thus moved forward in the fuse. At the same time the firing plunger "creeps" forward to its original position.

On impact, the firing plunger is driven back to the position it had during the "set back." The primer, however, has moved forward, so that the firing pin now comes in contact with it.

Safety.—The cover over the head of the firing plunger is painted red, and should not be removed.

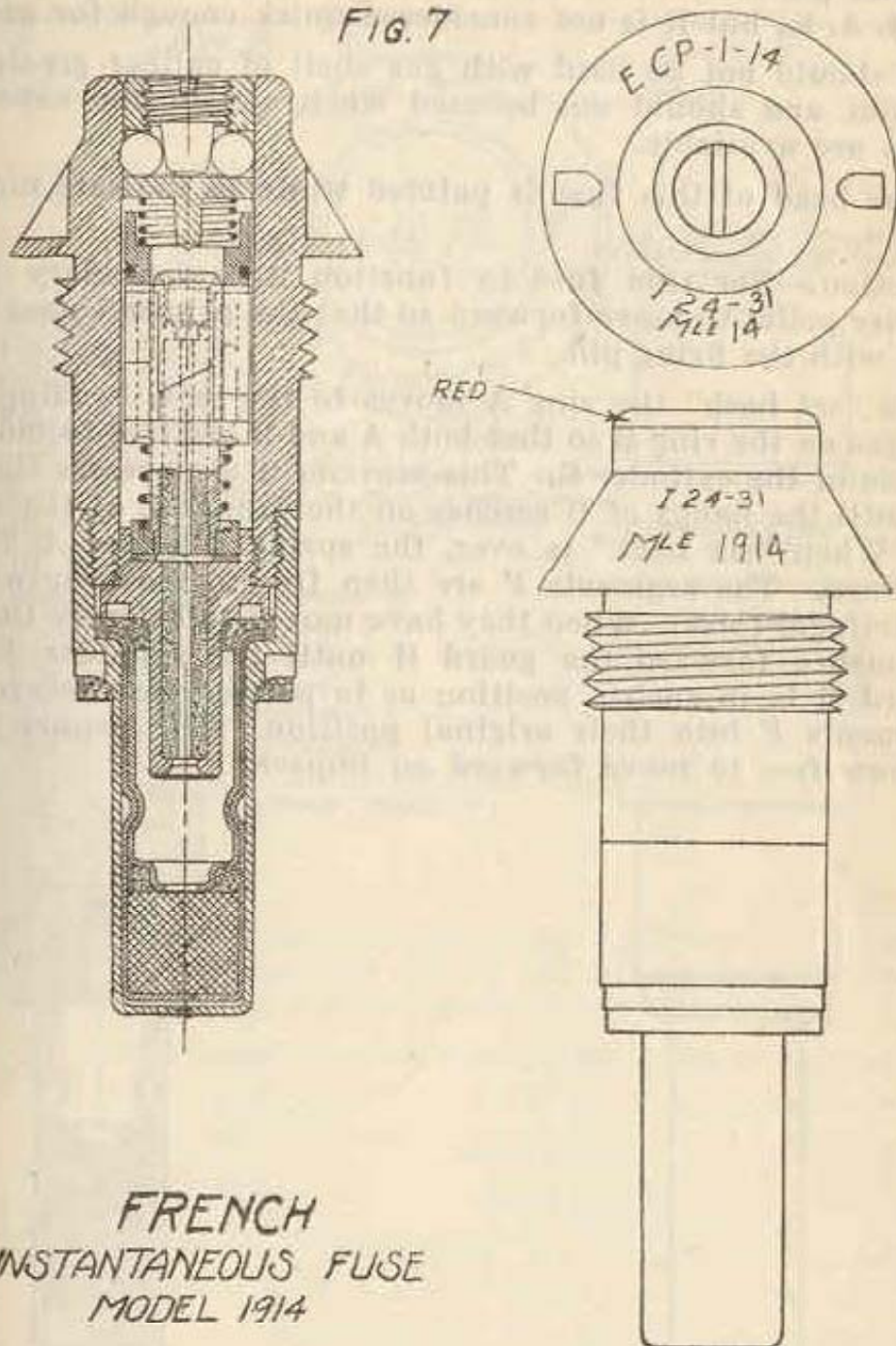
## FRENCH I MODEL 1914 FUSE.

(Fig. 7)

84. This is a fuse used extensively by the French for 75 mm. gas shell. The head of this use is usually painted red, though on certain models it is painted yellow.

It has not been adopted by our service as it is considered unsafe. The I Model 1914 Fuses is not to be used.

FIG. 7



FRENCH  
INSTANTANEOUS FUSE  
MODEL 1914

## FRENCH SCHNEIDER MODEL 1916 FUSE.

(Fig. 8)

85. This is a non-superquick fuse used by the French for 75 mm gas shell. It causes considerably less dispersion than the I. A. L., but it is not considered quick enough for gas shell.

It should not be used with gas shell of caliber greater than 75 mm. and should not be used when any of the super-quick fuses are available.

The head of this fuse is painted white to indicate non-delay action.

Action.—For this fuse to function it is necessary for the primer pellet to move forward so that the primer comes in contact with the firing pin.

On "set back" the ring A moves to the rear, bending up the flanges on the ring B so that both A and B are free to move back inside of the cylinder C. This movement compresses the spring D until the flangs of B catches on the prongs E of the cylinder C. When "set back" is over, the spring D forces A, B and C forward. The segments F are then free to move outwards by centrifugal force. When they have moved sufficiently the spring G pushes forward the guard H until the shoulder I of the guard H is in such a position as to prevent any return of the segments F into their original position. The primer pellet J is now free to move forward on impact.

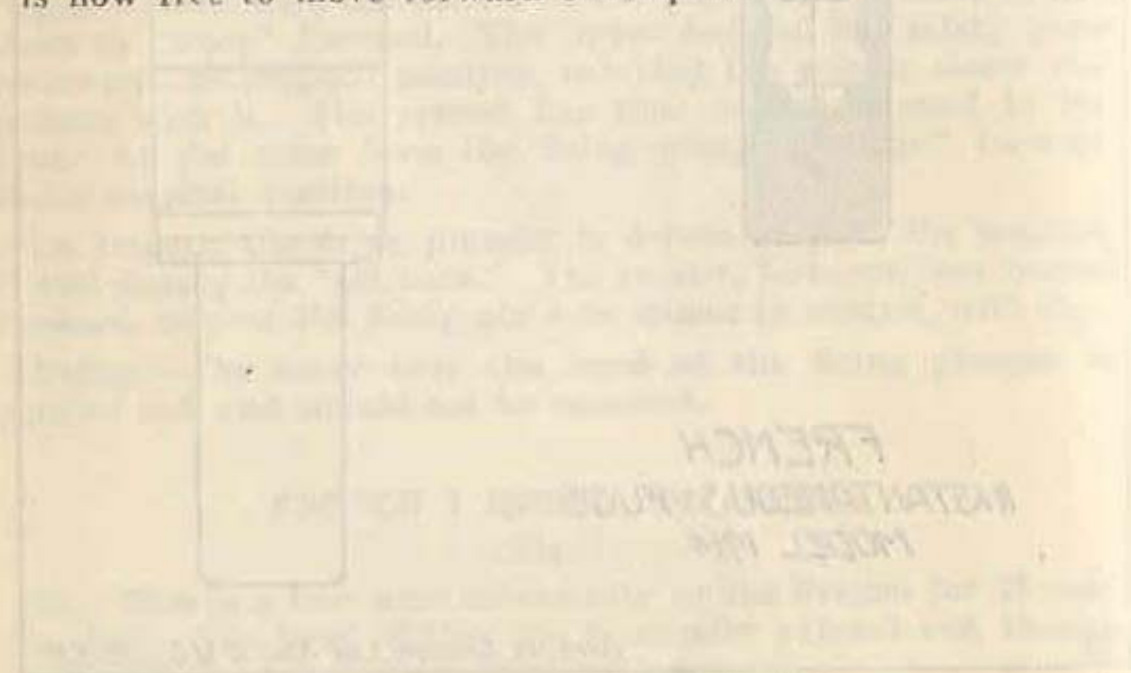
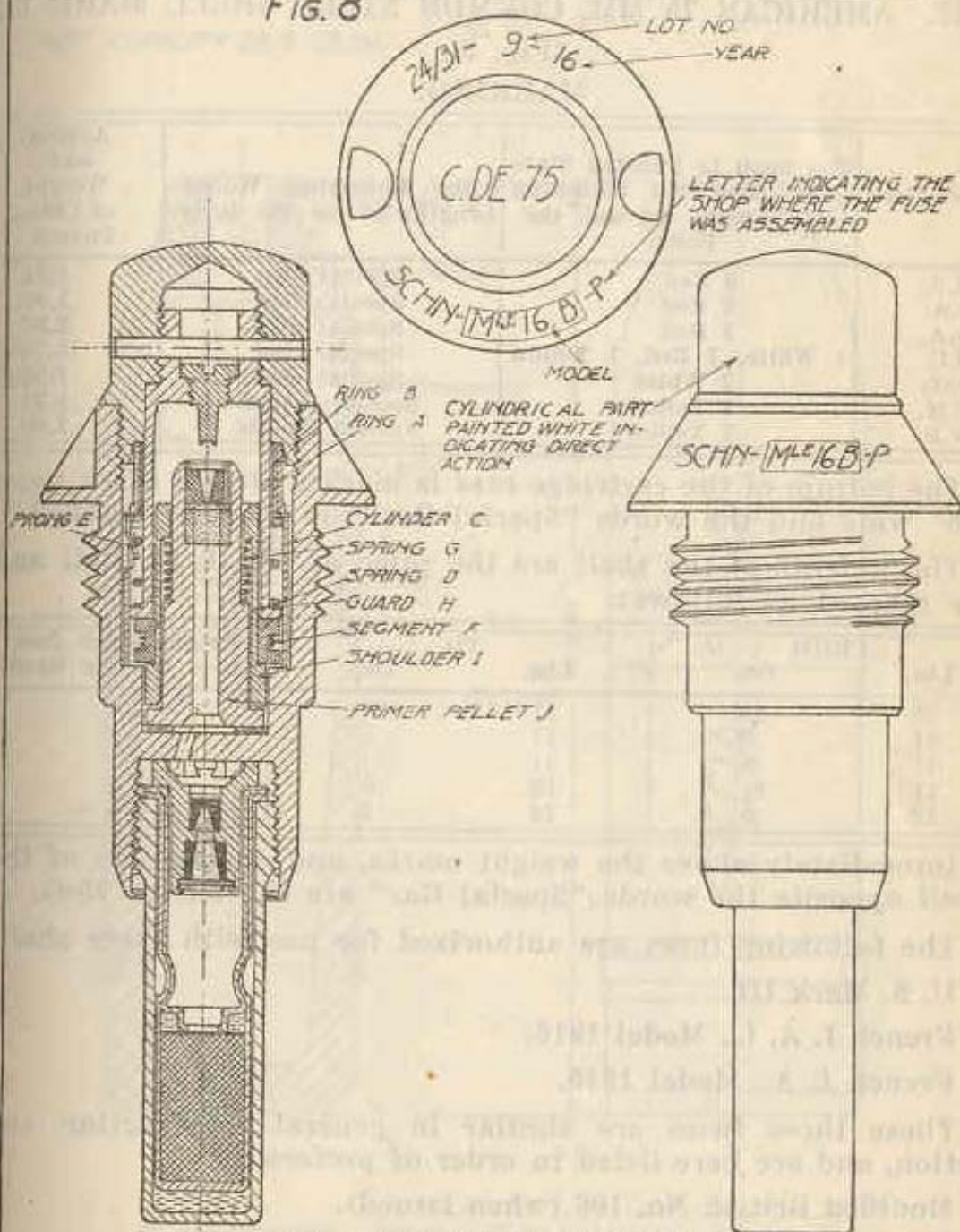


FIG. 8



SCHNIEDER MODEL 1916 FUSE

OFFENSE DIVISION, ENG. SEC. C.W.5. 5539

## MODIFIED BRITISH NO. 106 FUSE.

86. This is a fuse of the super-quick type and has only recently been adopted by us. It is suitable for all calibers and ranks next to the Mark III and I. A. L. fuses for chemical skill.

## 87. AMERICAN 75 MM. COMMON STEEL SHELL MARK II.

(Fig. 9.)

## MARKING.

Gases Used	The Shell Is Painted Slate Gray with the Following $\frac{1}{2}$ " Bands Around the Body.	The Following Words Lengthwise on the Body.	Approximate Weight of Cases. Pounds.
H.S.	3 Red	Special Gas	1.36
C.A.	2 Red	Special Gas	1.46
B.A.	1 Red	Special Gas	1.97
-N.C.	1 White, 1 Red, 1 Yellow	Special Gas	1.74
C.G.	2 White	Special Gas	1.32
F.M.	2 Yellow	Special Smoke	1.71
W.P.	1 Yellow	Special Smoke	1.90

The bottom of the cartridge case is marked with a black band  $\frac{3}{8}$ " wide and the words "Special Gas", or "Special Smoke".

The weights of the shell are the same as for H. E. shell and are marked as follows:

Lbs.	FROM Oz.	Lbs.	TO Oz.	Weight Mark Just Above Driving Band.
10	11	11	0	1.
11	0	11	5	+
11	5	11	11	++
11	11	12	0	+++
12	0	12	5	++++

Immediately above the weight marks, and on the side of the shell opposite the words "Special Gas" are the letters 75-G.

The following fuses are authorized for use with these shell:

U. S. Mark III.

French I. A. L., Model 1916.

French I. A., Model 1915.

These three fuses are similar in general construction and action, and are here listed in order of preference.

Modified British No. 106 (when issued).

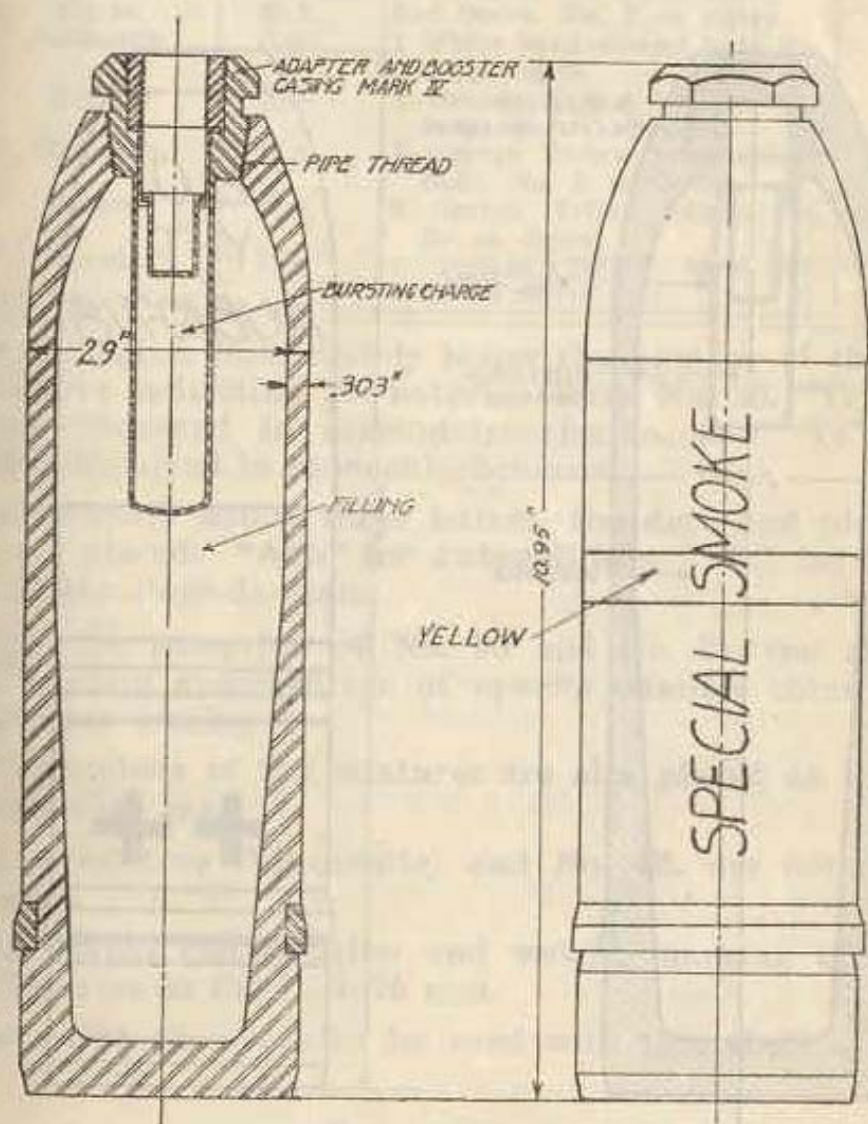
French R. Y.

French Schneider, Model 1916.

These last two fuses have not been adopted by our Service, but may be encountered by troops who are supplied from French Dumps. The Schneider Model 1916 is to be used only when other fuses are not available.

The French Model 1914 (red head) is not to be used. It is unsafe.

NET CAPACITY 28.6 CU. IN. **FIG. 9**



75<sup>MM</sup> COMMON STEEL SHELL MARK II

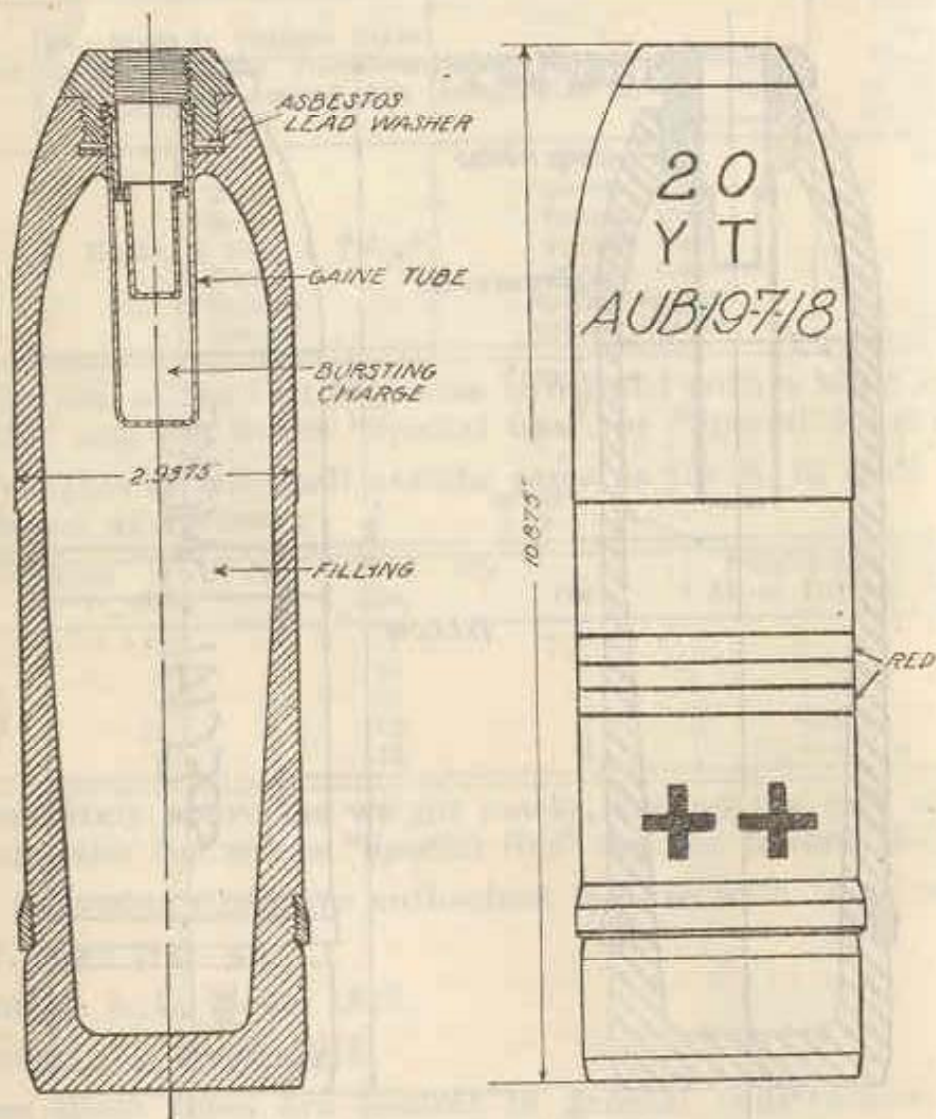
MARKING TYPICAL FOR W.P.

OFFENSE DIVISION, ENG. SEC. C.W.S. 5526

PLU

FIG. 10.

NET CAPACITY 29.5 CU. IN.



FRENCH 75<sup>mm</sup> STEEL SHELL MODEL 1915  
 MARKING TYPICAL FOR N°20 MIXTURE (H.S.)

OFFENSE DIVISION-ENG SEC-CVRS 5528

## FRENCH 75 MM. STEEL SHELL MODEL, 1915.

(Fig. 10)

88. The following are the 75 mm. French chemical shell in common use:

No.	Filling	U. S. Symbol	Marking	Weight of Gas in Pounds Approximate
			The shell is painted green with the following distinguishing marks	
2	Incendiary	Incendiary	Red Ogive, No. 2 on Ogive	....
3	Smoke	W.P.	Red Ogive, No. 3 on Ogive	1.06
5	Collongite	C.G.	1 White band around body No. 5 on Ogive	1.55
7	Aquinite	N.O.	1 Orange Yellow band around body, No. 7 on Ogive	1.76
9	Martonite	B.A.	1 Orange Yellow band around body, No. 9 on Ogive	1.34
20	Yperite	H.S.	2 Orange Yellow bands, No. 20 on Ogive	1.31
21	Camite	C.A.	1 Orange Yellow band No. 21 on Ogive	1.52

On the ogive, immediately below the number of the mixture, are letters indicating its nature. With No. 20, "Yt" indicates Yperite dissolved in carbontetrachloride, and "Yc" indicates Yperite dissolved in monochlorbenzene.

Immediately below these letters, the date and place of fillings are placed. "Aub" for Aubervilliers, "Vis" for Vincennes, "P.Cx" for Pont-de-Claix.

With the exception of No. 20 and No. 21, the above mixtures contain a percentage of opacite (stannic chloride) added to produce smoke.

The numbers of the mixtures are also placed on the base of the cartridge case.

No. 4 mixture (Vincennite) and No. 4B, are not authorized for use.

The weight classification and weight marking of this shell are the same as the U. S. 75 mm.




The same fuses are to be used with this shell as with the U. S. 75 mm.

# 89. AMERICAN 4.7" COMMON STEEL SHELL. MARK II. (Fig. 11.)

GASES USED	SHELL IS PAINTED SLATE GRAY		APPROXIMATE WEIGHT OF GASES, LBS.
	WITH THE FOLLOWING 1/2" BANDS AROUND THE BODY	AND FOLLOWING WORDS LENGTHWISE ON THE BODY	
H.S.	3 Red	Special Gas	4.38
C.A.	2 Red	Special Gas	4.44
B.A.	1 Red	Special Gas	6.36
P.S.	1 Red—1 White	Special Gas	5.3
N.C.	1 Red—1 White—1 Yellow	Special Gas	5.62
C.G.	2 White	Special Gas	4.27
F.M.	2 Yellow	Special Smoke	5.53
W.P.	1 Yellow	Special Smoke	6.14

The bottom of the cartridge case is marked with a black band 3/8" wide and the words "Special Gas," "Special Smoke" or "Incendiary."

The weights of the shell are the same as for H. E. and are marked as follows:

FROM		TO		WEIGHT MARK JUST BELOW BOURRELET
43 Lbs.	0 Ozs.	43 Lbs.	11 Ozs.	
43 Lbs.	11 Ozs.	44 Lbs.	6 Ozs.	
44 Lbs.	6 Ozs.	45 Lbs.	1 Ozs.	

The weight marks are 1/2" squares with a center-punch mark in the center of each square.

Immediately above the driving band are stencilled the letters 4.7 G.

The following fuses are authorized for use with this shell:

U. S. Mark III.

French I. A. L. Model 1916.

French I. A. Model 1915.

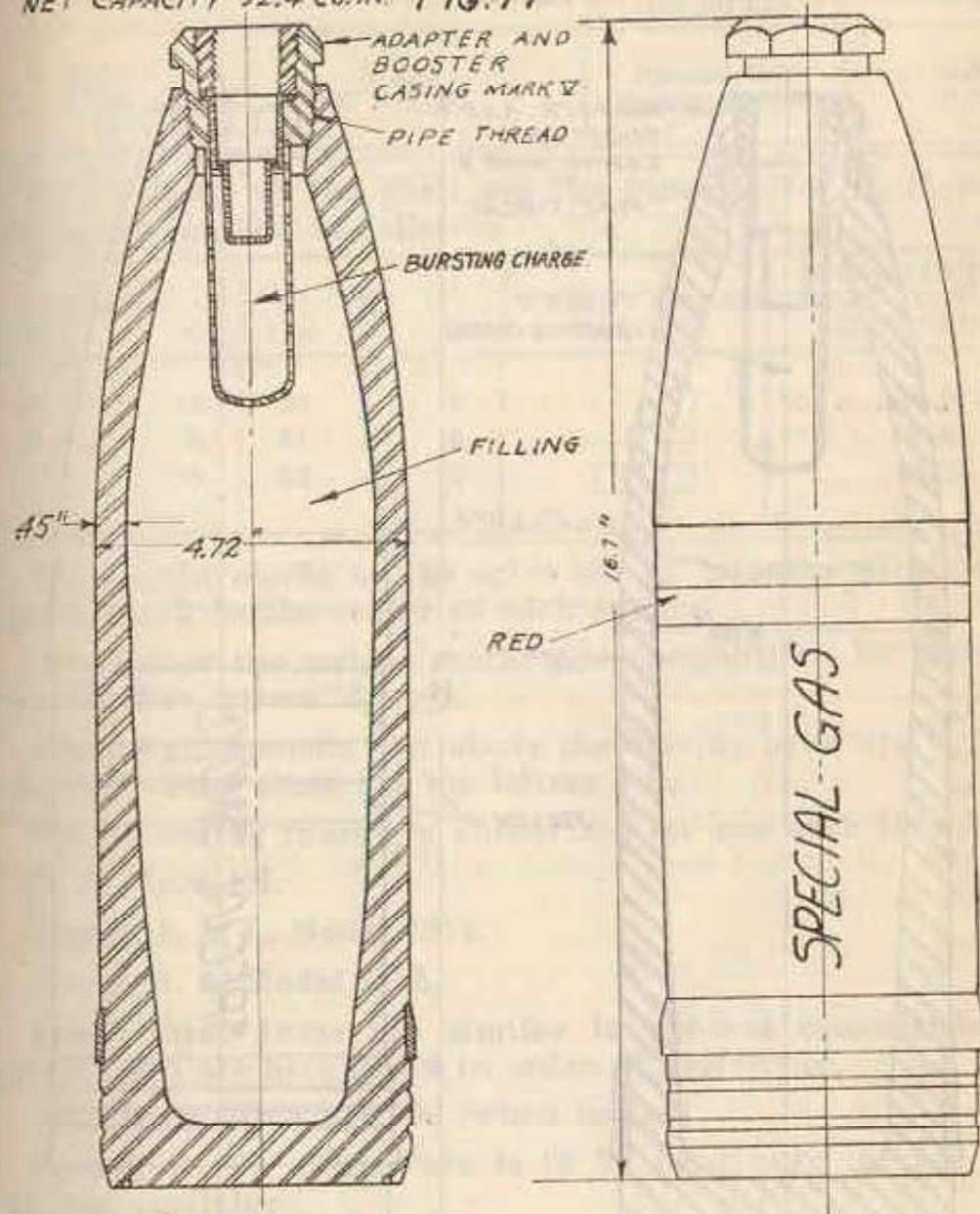
These three fuses are similar in general construction and action, and are here listed in order of preference.

Modified British No. 106 (when issued).

French R. Y. (This fuse is only to be used in case others are not available.)

A 4.7" semi-steel shell Mark V has also been developed which differs from the steel shell only in that the net capacity is reduced from 92.4 cu. in. to 90.9 cu. in.

NET CAPACITY 92.4 CU. IN. FIG. 11



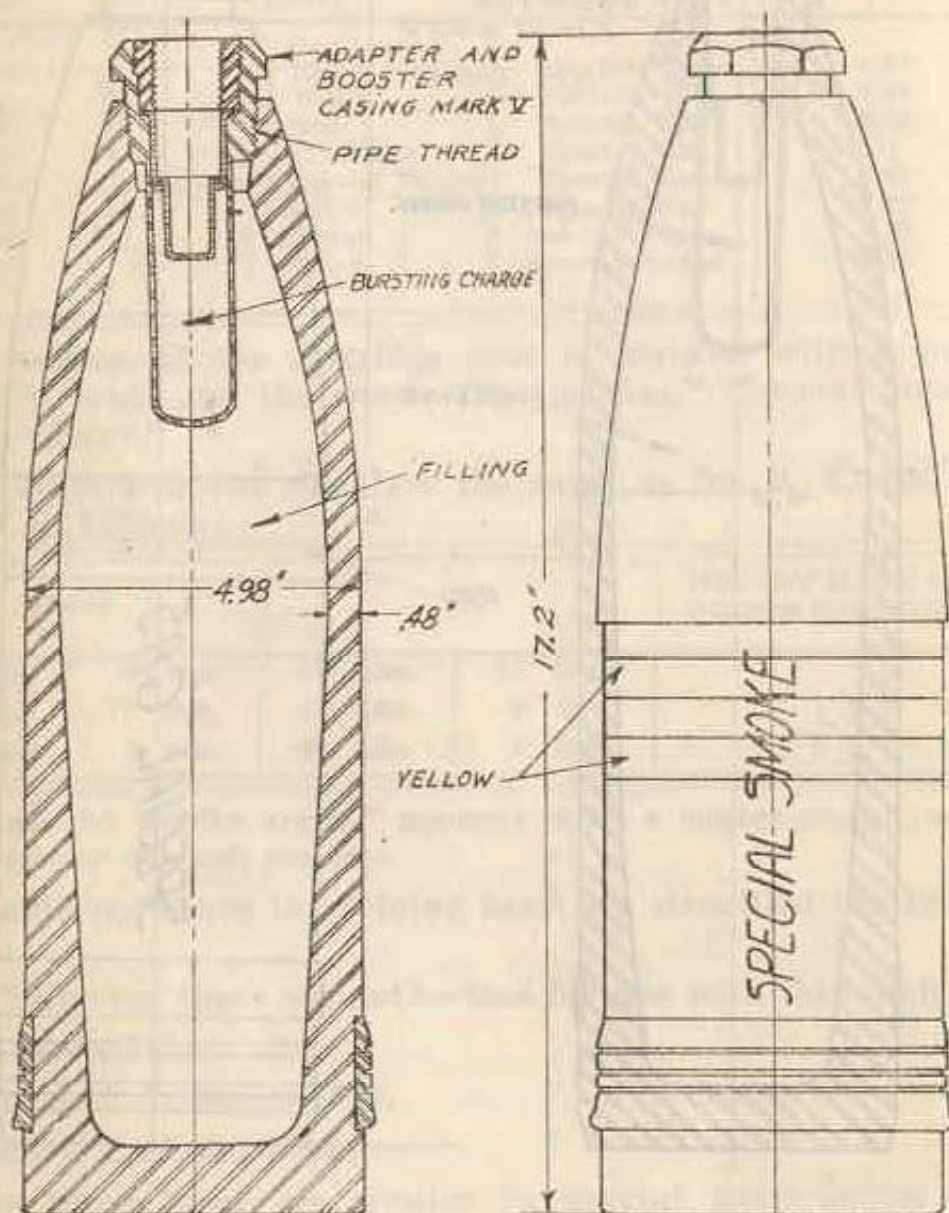
4.7 IN. COMMON STEEL SHELL MARK II

MARKING TYPICAL FOR B.A.

OFFENSE DIVISION, ENG. SEC. C.W.S. 5532

NET CAPACITY 113 CU. IN.

FIG. 12



5 IN. COMMON STEEL SHELL POINT FUSE MARK VI

MARKING TYPICAL FOR F.M.



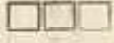
OFFENSE DIVISION, ENG. SEC. C.W.O. 5525

701

# 90. AMERICAN 5-INCH COMMON STEEL SHELL MARK VI. (Fig. 12.)

GASES USED	SHELL IS PAINTED SLATE GRAY		APPROXIMATE WEIGHT OF GASES
	WITH THE FOLLOWING 1/2" BANDS AROUND BODY	AND FOLLOWING WORDS LONGITUDINAL ON SHELL	
H.S. F.M.	3 Red 2 Yellow	Special Gas Special Smoke	5.38 0.79

The weights of the shell are the same as for H. E. and the shells are marked as follows:

FROM		TO		WEIGHT MARKS ON OGIVE	WEIGHTS STENCILLED JUST ABOVE DRIVING BAND
Lbs.	Oz.	Lbs.	Oz.		
40	11	50	8		50.10
50	8	51	5		50.90
51	5	52	2		51.70

The weight marks on the ogive are 1/2" squares with a center-punch mark in the center of each square.

Just below the weight marks the ammunition lot number is stencilled in letters 1" high.

The weight stencils just above the driving band are 1" letters, and just above them are the letters 5-G.

The following fuses are authorized for use with this shell:

U. S. Mark III.

French I. A. L. Model 1916.

French I. A. Model 1915.

These three fuses are similar in general construction and action, and are here listed in order of preference.

Modified British No. 106 (when issued).

French R. Y. (This fuse is to be used only in case others are not available).



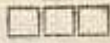
A 5-inch semi-steel shell has also been developed which differs from the steel shell only in reduced capacity.

91. AMERICAN 6-INCH COMMON STEEL SHELL,  
MARK III, FOR GUN.

(Fig. 13.)

GASES USED	SHELL IS PAINTED SLATE GRAY		APPROXIMATE WEIGHT OF GASES, LBS.
	WITH THE FOLLOWING 1/2" BANDS AROUND BODY	AND FOLLOWING WORDS LENGTHWISE ON BODY	
H.S. F.M.	3 Red 2 Yellow	Special Gases Special Smoke	10.50 13.28

The weights of the shell are the same as for H. E. and the shells are marked as follows:

LBS.	OZS	LBS.	OZS	WEIGHT MARKS ON OGIVE	WEIGHT STENCIL JUST ABOVE DRIVING BAND
86	14	88	4		87.56
88	4	89	10		88.94
89	10	91	1		90.34

The weight marks on the ogive are  $\frac{1}{2}$ " squares with a prick punch mark in the center of each square.

Just below the weight marks the ammunition lot number is stencilled in letters 1" high.

The weight stencils just above the driving band are 1" letters, and just above them are the letters 6-G.

The following fuses are authorized for use with this shell:

U. S. Mark III.

French I. A. L. Model 1916.

French I. A. Model 1915.

These three fuses are similar in general construction and action, and are here listed in order of preference.

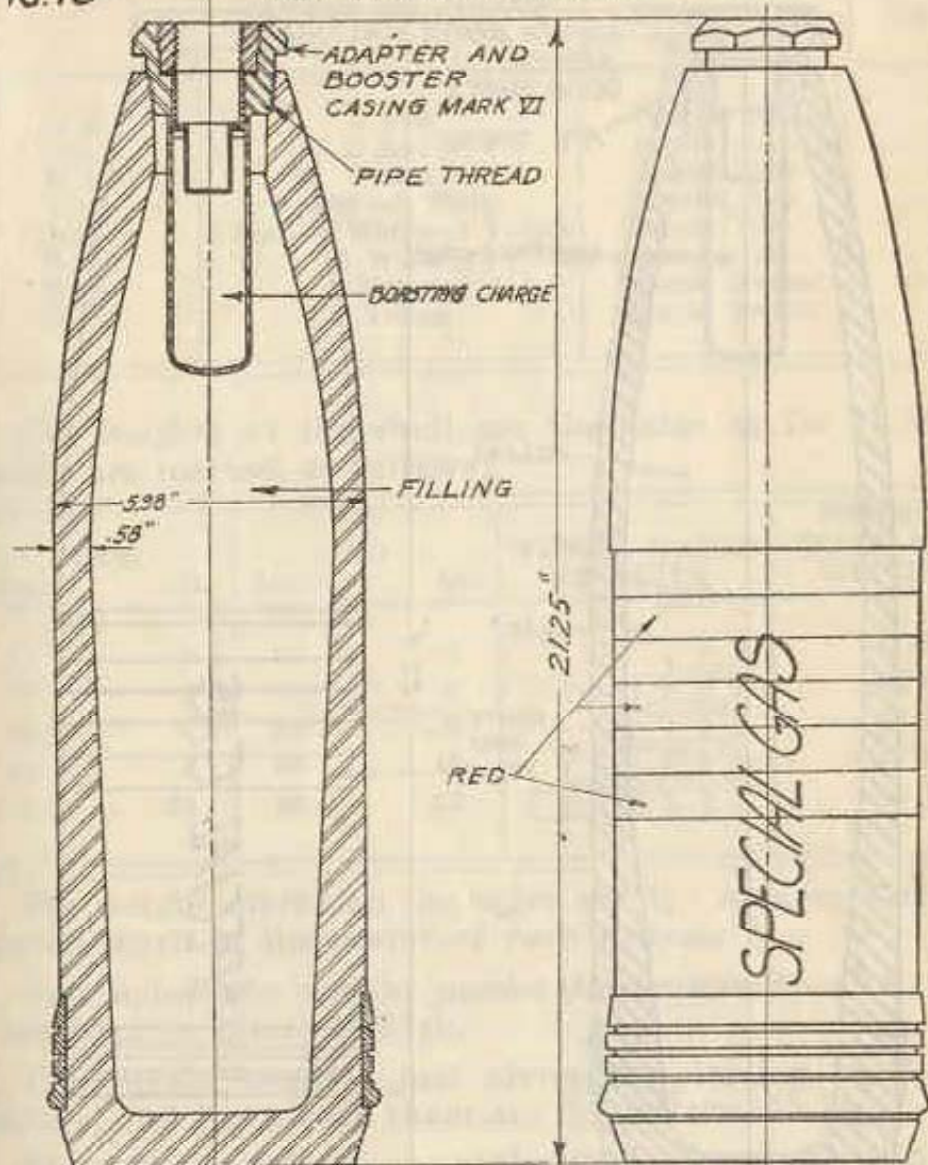
Modified British No. 106 (when issued).

French R. Y. (This fuse is to be used only in case others are not available).

A 6-inch semi-steel shell has also been developed which differs from the steel shell only in reduced capacity.

FIG. 13

NET CAPACITY 221 CU. IN.

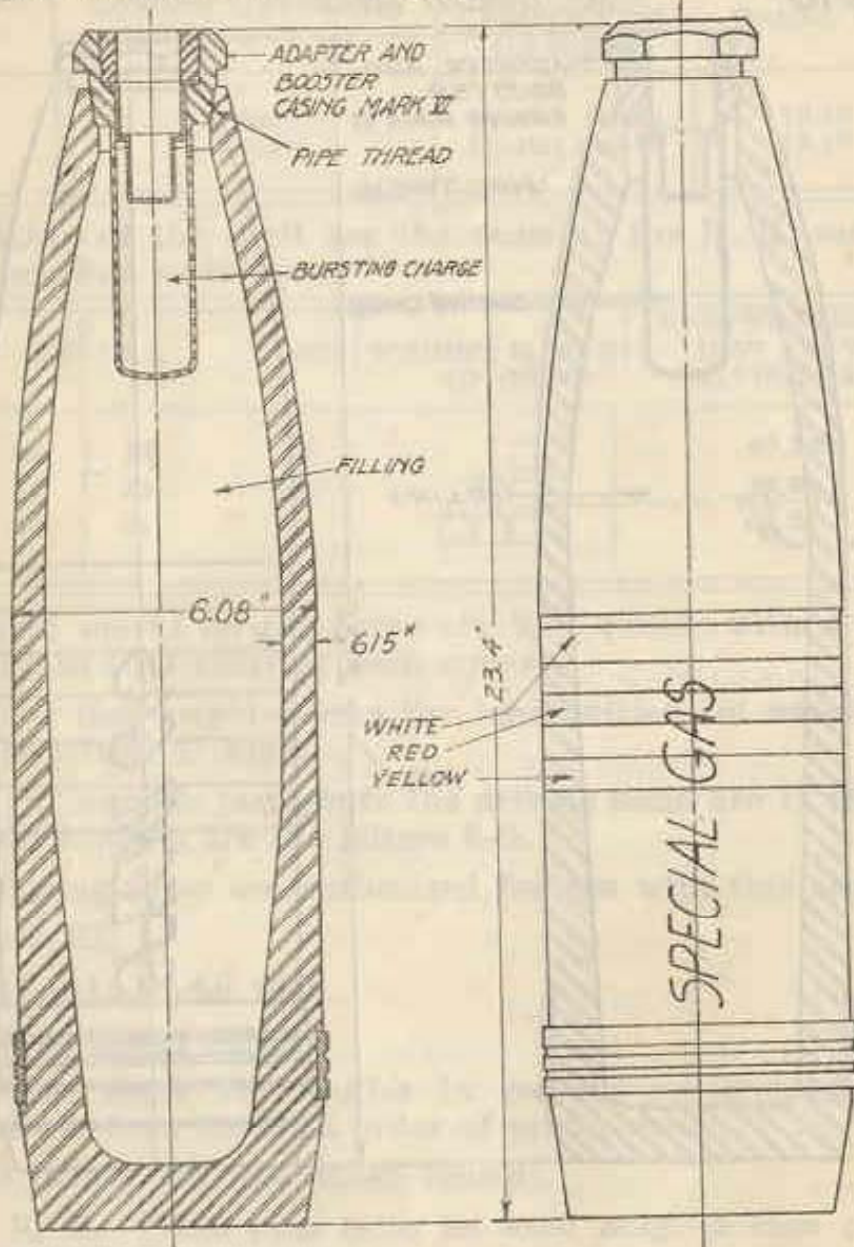


6 IN. COMMON STEEL SHELL MARK III  
MARKING TYPICAL FOR H.5.

OFFENSE DIVISION, ENG. SEC. C.W. 3,5531

NET CAPACITY 238 CU. IN.

FIG. 14



155mm COMMON STEEL SHELL MARK II FOR HOWITZER

MARKING TYPICAL FOR N.C.


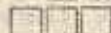

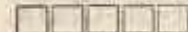

OFFENSE DIVISION, ENG SEC. C.W.S. 5533

92. AMERICAN 155 MM. COMMON STEEL SHELL,  
MARK II, FOR HOWITZER.

(Fig. 14.)

GASES	SHELL IS PAINTED SLATE GRAY		
	WITH THE FOLLOWING 1/2" BANDS AROUND BODY	AND FOLLOWING WORDS LENGTHWISE ON BODY	APPROXIMATE WEIGHT OF GASES, LBS.
H.S.	3 Red	Special Gas	11.3
C.A.	2 Red	Special Gas	12.18
B.A.	1 Red	Special Gas	16.41
P.S.	1 Red—1 White	Special Gas	13.66
N.C.	1 Red—1 White—1 Yellow	Special Gas	14.5
C.G.	2 White	Special Gas	11.01
F.M.	2 Yellow	Special Smoke	14.30
W.P.	1 Yellow	Special Smoke	15.85

The weights of the shell are the same as for H. E. and the shells are marked as follows:

FROM		TO		WEIGHT MARKS ON OGIVE	WEIGHTS STENCILLED JUST ABOVE DRIVING BAND
Lbs.	Oz.	Lbs.	Oz.		
91	3	92	5		41 K 700
92	5	93	6		42 K 200
93	6	94	8		42 K 700
94	8	95	10		43 K 200
95	10	96	12		43 K 200

The weight marks on the ogive are  $\frac{1}{2}$ " squares with a center-punch mark in the center of each square.

Just below the weight marks the ammunition lot number is stencilled in letters 1" high.

The weight stencils just above the driving band are in 1" letters, and just above them are the letters 155 H.

The following fuses are authorized for use with this shell:

U. S. Mark III.

French I. A. L. Model 1916.

French I. A. Model 1915.

These three fuses are similar in general construction and action, and are here listed in order of preference.

Modified British No. 106 (when issued).

French R. Y. (This fuse is to be used only in case others are not available).

A 155 mm. semi-steel shell has also been developed which differs from the steel shell only in reduced capacity.

93. FRENCH 155 MM. SEMI-STEEL SHELL,  
MODEL 1915, FOR HOWITZER.

(Fig. 15.)

The following are the 155 mm. howitzer French chemical shell in common use:

FILLING		U. S. SYMBOL	MARKING The Shell Is Painted Green with the Following Distinguishing Marks.	APPROX- WT. OF GAS, LBS.
No.	Name			
Type Naud	Incendiary	Incendiary	Red ogive—1 black ring.....	..
5	Collongite	C.G.	1 White band around body— No. 5 on ogive.....	9.0
7	Aquinite	N.G.	1 Orange Yellow band around body—No. 7 on ogive.....	10.7
9	Martonite	B.A.	1 Orange Yellow band around body—No. 9 on ogive.....	7.46
20	Yperite	H.S.	2 Orange Yellow bands— No. 20 on ogive.....	7.6
21	Camite	C.A.	1 Orange Yellow band— No. 21 on ogive.....	8.83

On the ogive, immediately below the number of the mixture are letters indicating the nature of the mixture. With No. 20, "Yt" indicates Yperite dissolved in carbontetrachloride, and "Yc" indicates Yperite dissolved in monochlorbenzene.

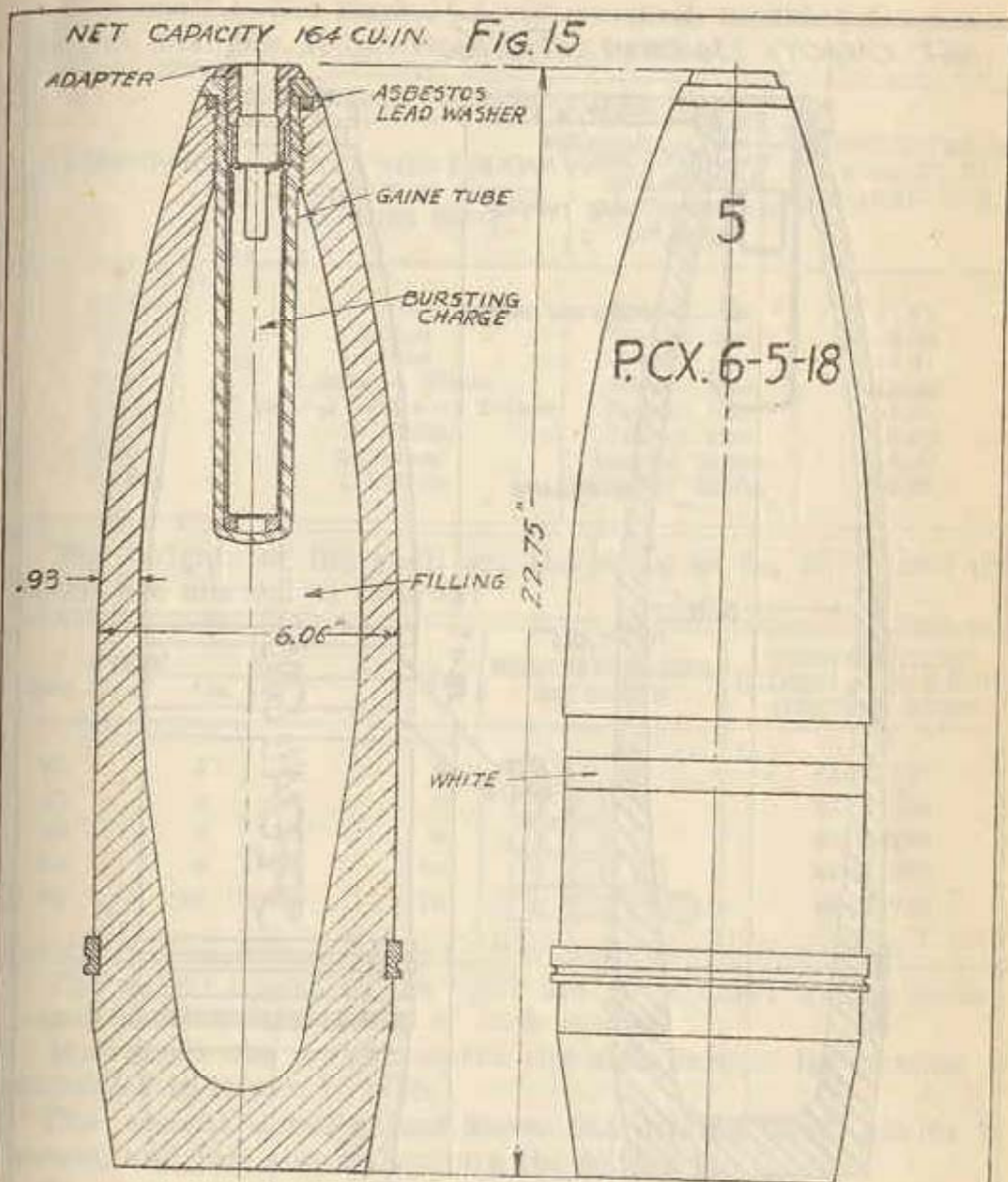
Immediately below these letters are indicated the date and place of filling: "Aub" for Aubervilliers, "Vis" for Vincennes, and "P.Cx" for Pont-de-Claix.

With the exception of No. 20 and No. 21, the above mixtures contain a percentage of Opacite (stannic chloride) added to produce smoke.

The No. 4 (Vicennite) and No. 4B are not authorized for use.

The weight classification and weight markings of this shell are the same as for the U. S. 155 mm. howitzer shell.

A limited number of the Model 1914 steel shell are filled with No. 4 and No. 5 mixtures. The steel shell has a greater capacity than the semi-steel and the markings of the two are similar.



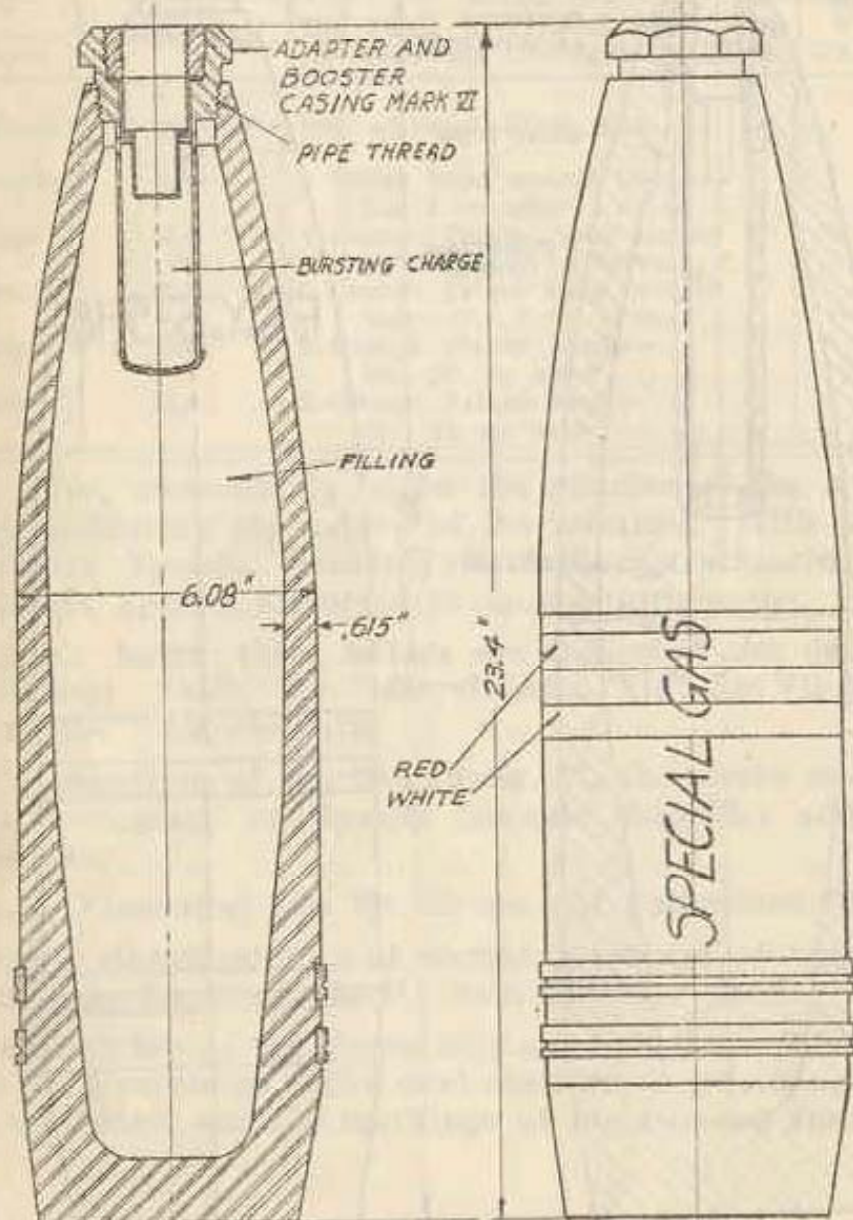
FRENCH

155<sup>MM</sup> SEMI STEEL SHELL MODEL 1915 FOR HOWITZER.

MARKING TYPICAL FOR N°5 MIXTURE (C.G.)

OFFENSE DIVISION, ENG. SEC. C.W.S. 5530

NET CAPACITY 238 CU. IN. FIG. 16.



155<sup>mm</sup> COMMON STEEL SHELL MARK VII FOR GUN.

MARKING TYPICAL FOR P.S.

OFFENSE DIVISION, ENG. SEC. CWS. 5527


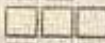


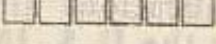
# 94. AMERICAN 155 MM. COMMON STEEL SHELL MARK VII. FOR GUN.

(Fig. 16)

This shell is the Mark II howitzer shell, modified for use in the 155 mm. gun. It has two driving bands.

GASES USED	SHELL IS PAINTED SLATE GRAY		APPROXIMATE WEIGHT OF GASES, LBS.
	WITH THE FOLLOWING 1/2" BANDS AROUND BODY	AND FOLLOWING WORDS LENGTHWISE ON BODY	
H.S.	3 Red	Special Gas	11.30
C.A.	2 Red	Special Gas	12.18
B.A.	1 Red	Special Gas	10.41
P.S.	1 Red—1 White	Special Gas	13.66
N.C.	1 Red—1 White—1 Yellow	Special Gas	14.50
C.G.	2 White	Special Gas	11.00
F.M.	2 Yellow	Special Smoke	14.30
W.P.	1 Yellow	Special Smoke	15.85

The weights of the shell are the same as for H. E. and the shells are marked as follows:

Lbs.	FROM Oz.	Lbs.	Oz.	WEIGHT MARKS ON OGIVE	WEIGHTS STENCILLED JUST ABOVE DRIVING BAND
91	3	92	5		41 K 700
92	5	93	6		42 K 200
93	6	94	8		42 K 700
94	8	95	10		43 K 200
95	10	96	12		43 K 700

The weight marks on the ogive are 1/2" squares with a center-punch mark in the center of each square.

Just below the weight marks the ammunition lot number is stencilled in letters 1" high.

The weight stencils, just above the driving band, are in 1" letters, and just above them are the letters 155 G.

The following fuses are authorized for use with this shell:  
U. S. Mark III.

French I. A. L. Model 1916.

French I. A. Model 1915.

These three fuses are similar in general construction and action, and are here listed in order of preference.

Modified British No. 106 (when issued).

French R. Y. (This fuse is to be used only in case others are not available).

A 155 mm. semi-steel shell has also been developed which differs from the steel shell only in reduced capacity.

# 95. FRENCH 155 MM. SEMI-STEEL SHELL MODEL 1917. FOR GUN.

(Fig. 17.)

This shell is the model 1915 howitzer shell modified for use in the 155 mm. gun. It has two driving bands.

The following are the 155 mm. howitzer French chemical shell in common use:

FILLING		U. S. SYMBOL	MARKING The Shell Is Painted Green with the Following Distinguishing Marks.	APPROX- IMATE WT. OF GAS, LBS.
No.	Name			
5	Collongite	C.G.	1 White band around body— No. 5 on ogive.....	9.0
7	Aquinite	N.C.	1 Orange yellow band around body—No. 7 on ogive.....	10.7

On the ogive, immediately below the number of the mixture are letters indicating the nature of the mixture.

Immediately below these letters are indicated the date and place of filling "Aub" for Aubervilliers, "Vis" for Vincennes, and "P.Cx" for Pont-de-Claix.

On the body are the letters G.P. in white, indicating that it is a gun shell.

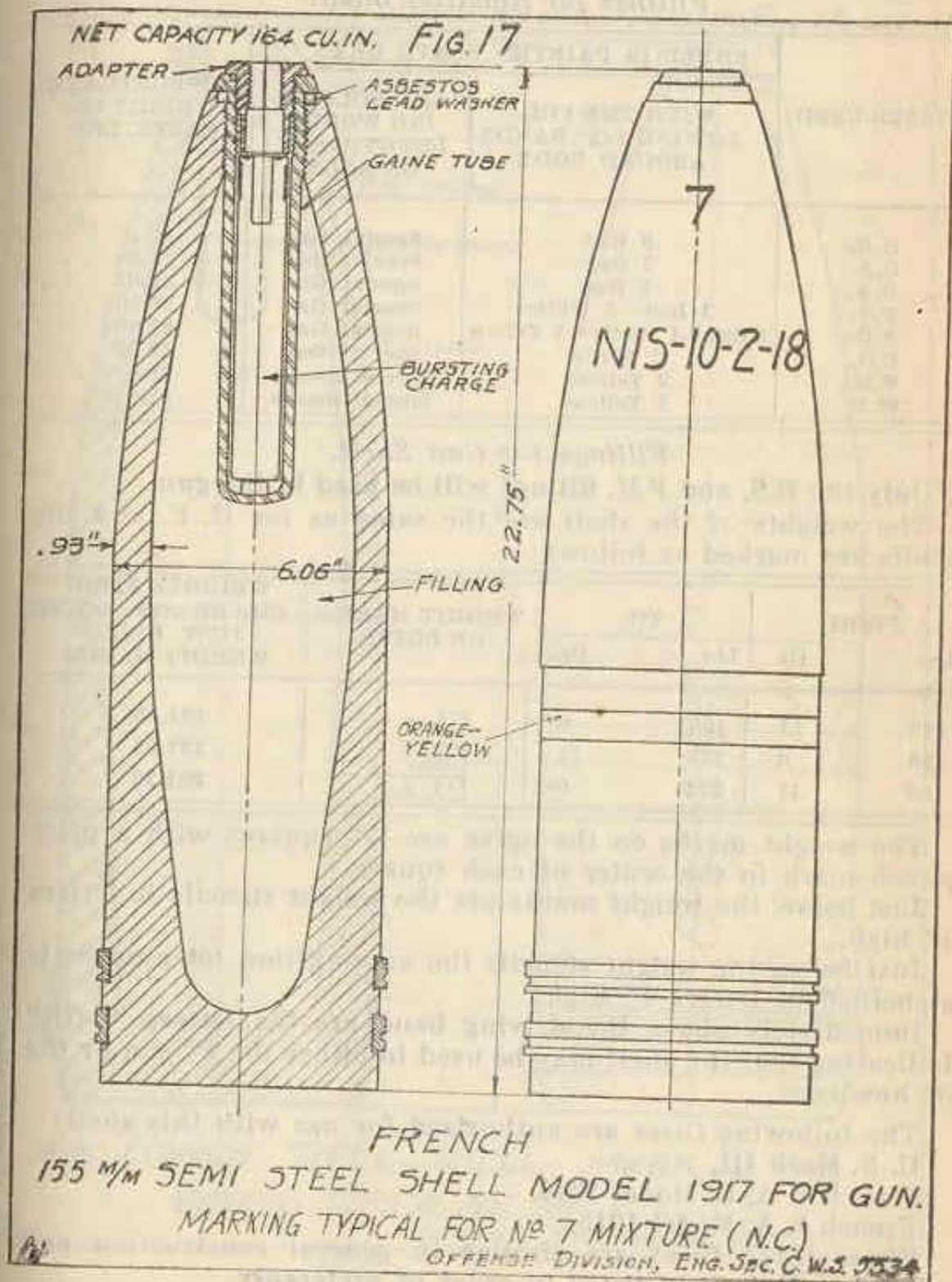
The above mixtures contain a percentage of Opacite (stannic chloride) added to produce smoke.

The No. 4 mixture (Vincennite) and No. 4B are not authorized for use.

The weight classifications and weight markings of this shell are the same as for the U. S. 155 mm. gun shell.

The same fuses are to be used with this shell as with the U. S. 155 mm. gun shell.

A limited number of the Model 1915 steel shell are filled with No. 4 and No. 5 mixtures. The steel shell has a greater capacity than the semi-steel shell. The markings of the two are similar.



# 96. AMERICAN 8-INCH COMMON STEEL SHELL MARK III. (Fig. 18.)




The same shell is used for both howitzer and gun.  
*Fillings for Howitzer Shell.*

GASES USED	SHELL IS PAINTED SLATE GRAY		APPROXIMATE WEIGHT OF GASES, LBS.
	WITH THE FOLLOWING 1/2" BANDS AROUND BODY	AND FOLLOWING WORDS LENGTHWISE ON BODY	
H.S.	3 Red	Special Gas	22.45 ✓
C.A.	2 Red	Special Gas	24.20
B.A.	1 Red	Special Gas	32.67
P.S.	1 Red—1 White	Special Gas	27.20
N.C.	1 Red—1 White—1 Yellow	Special Gas	28.90
G.G.	2 White	Special Gas	22.05
F.M.	2 Yellow	Special Smoke	28.4
W.P.	1 Yellow	Special Smoke	31.5 ✓

## *Fillings for Gun Shell.*

Only the H.S. and F.M. fillings will be used in the gun.

The weights of the shell are the same as for H. E. and the shells are marked as follows:

FROM		TO		WEIGHT MARKS ON OGIVE	WEIGHTS STENCILED ON OGIVE JUST BELOW WEIGHT MARKS
Lbs.	Oz.	Lbs.	Oz.		
192	11	195	6		194.58
195	6	198	11		197.88
198	11	202	0		201.20

The weight marks on the ogive are 1/2" squares with a prick punch mark in the center of each square.

Just below the weight marks are the weight stencils in letters 1" high.

Just below the weight stencils the ammunition lot number is stencilled in letters 1" high.

Immediately above the driving band are the letters "8-GH" indicating that the shell may be used in either the 8" gun or the 8" howitzer.

The following fuses are authorized for use with this shell:  
U. S. Mark III.

French I. A. L. Model 1916.

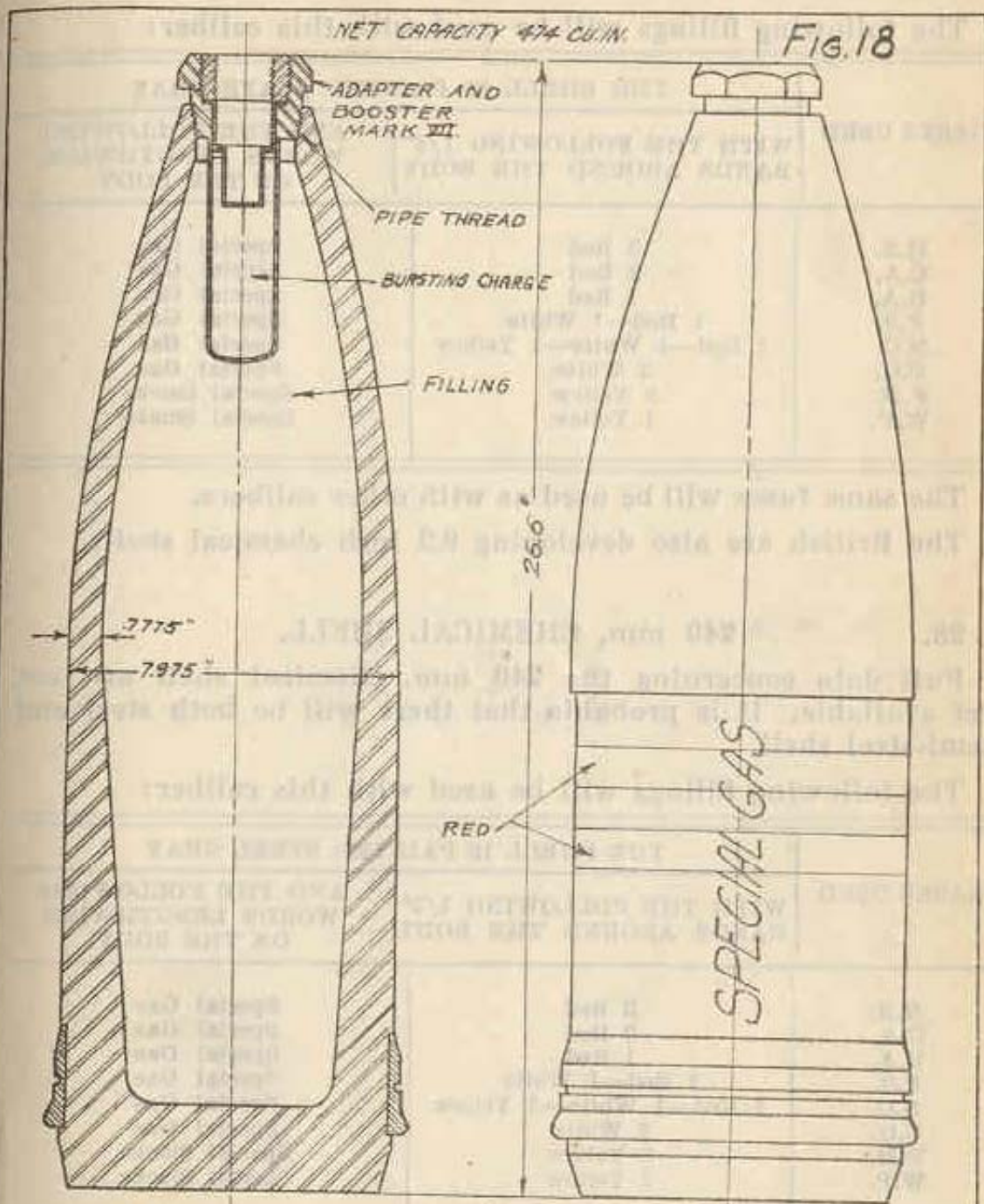
French I. A. Model 1915.

These three fuses are similar in general construction and action, and are here listed in order of preference.

Modified British No. 106 (when issued).

French R. Y. (This fuse is to be used only in case others are not available).

An 8" semi-steel shell has also been developed which differs from the steel shell in reduced capacity only.



8 IN. COMMON STEEL SHELL MARK III  
MARKING TYPICAL FOR DA.

OFFENSE DIVISION, ENG. SEC. C.W.S. 5529

## 97. 9.2 INCH CHEMICAL SHELL.

Full data concerning the 9.2 inch chemical shell are not yet available. It is probable that there will be both steel and semi-steel shell.

The following fillings will be used with this caliber:

GASES USED	THE SHELL IS PAINTED SLATE GRAY	
	WITH THE FOLLOWING 1/2" BANDS AROUND THE BODY	AND THE FOLLOWING WORDS LENGTHWISE ON THE BODY
H.S.	3 Red	Special Gas
C.A.	2 Red	Special Gas
B.A.	1 Red	Special Gas
P.S.	1 Red—1 White	Special Gas
N.C.	1 Red—1 White—1 Yellow	Special Gas
C.G.	2 White	Special Gas
F.M.	2 Yellow	Special Smoke
W.P.	1 Yellow	Special Smoke

The same fuses will be used as with other calibers.

The British are also developing 9.2 inch chemical shell.

## 98. 240 mm. CHEMICAL SHELL.

Full data concerning the 240 mm. chemical shell are not yet available. It is probable that there will be both steel and semi-steel shell.

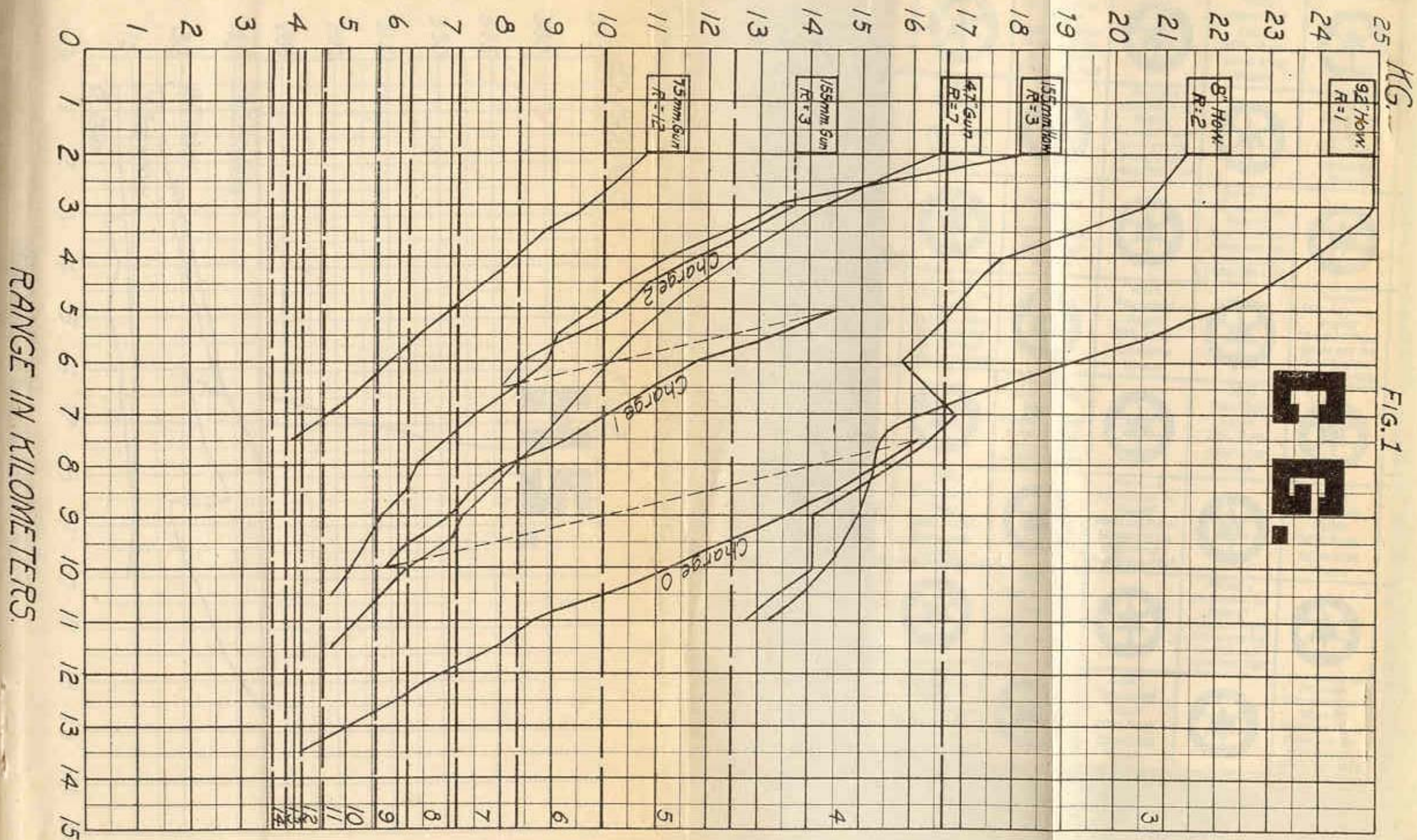
The following fillings will be used with this caliber:

GASES USED	THE SHELL IS PAINTED STEEL GRAY	
	WITH THE FOLLOWING 1/2" BANDS AROUND THE BODY	AND THE FOLLOWING WORDS LENGTHWISE ON THE BODY
H.S.	3 Red	Special Gas
C.A.	2 Red	Special Gas
B.A.	1 Red	Special Gas
P.S.	1 Red—1 White	Special Gas
N.C.	1 Red—1 White—1 Yellow	Special Gas
C.G.	2 White	Special Gas
F.M.	2 Yellow	Special Smoke
W.P.	1 Yellow	Special Smoke

The same fuses will be used as with other calibers.

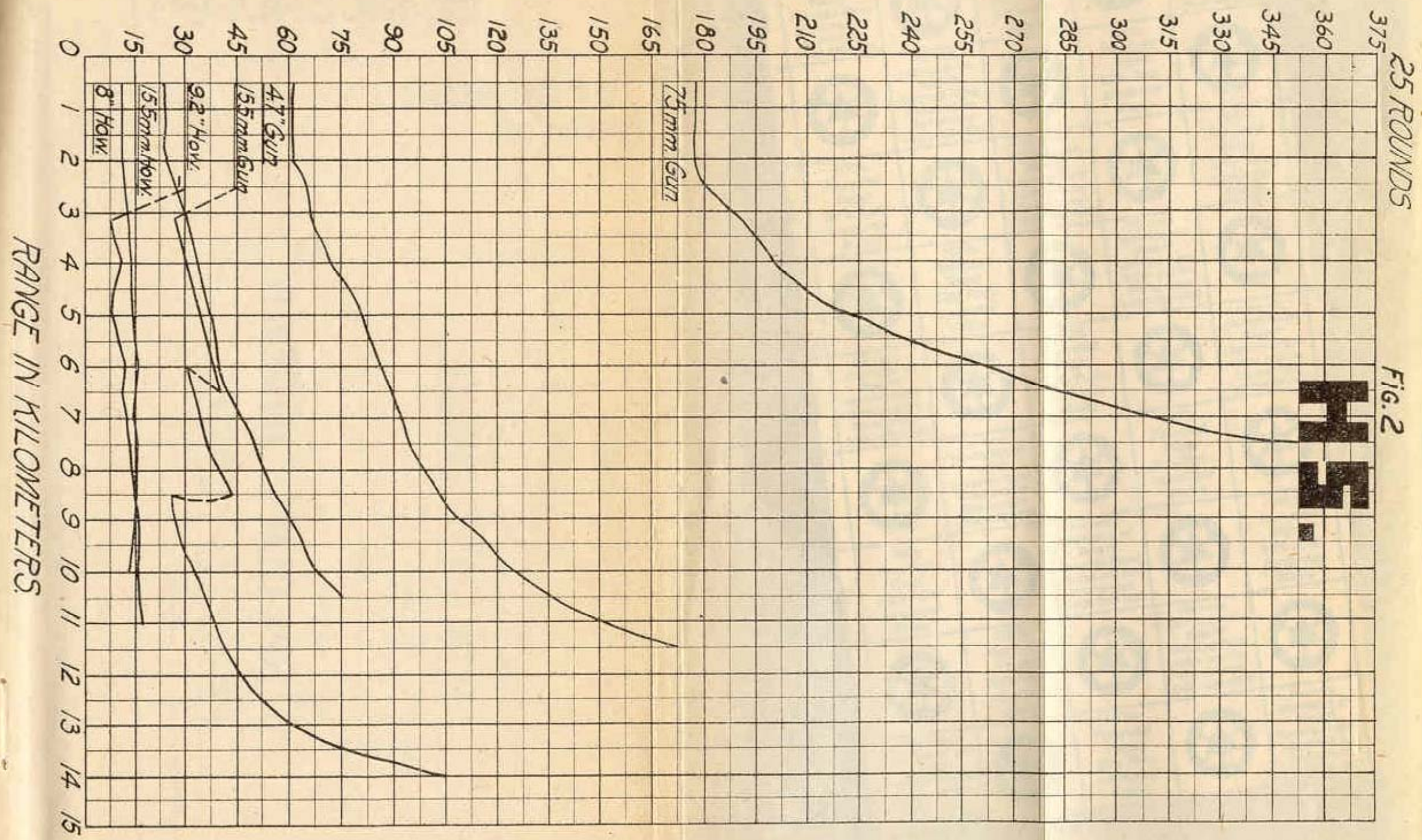
The British are also developing 9.2 inch chemical shell.

KILOGRAMS OF C.G. EFFECTIVE PER 50 METER FRONT WHEN FIRED  
FROM ONE GUN IN TWO MINUTES AT "R" RATE OF FIRE-LETHAL DOSE 50 KGS. R-ROUNDS PER MINUTE.



NUMBER OF GUNS REQUIRED TO PRODUCE A LETHAL DOSE PER 50 METER FRONT.

NUMBER OF ROUNDS PER UNIT AREA-100 METERS X 100 METERS.  
 ASSUMING THAT 100 KG. ARE NECESSARY PER UNIT AREA.



10,239

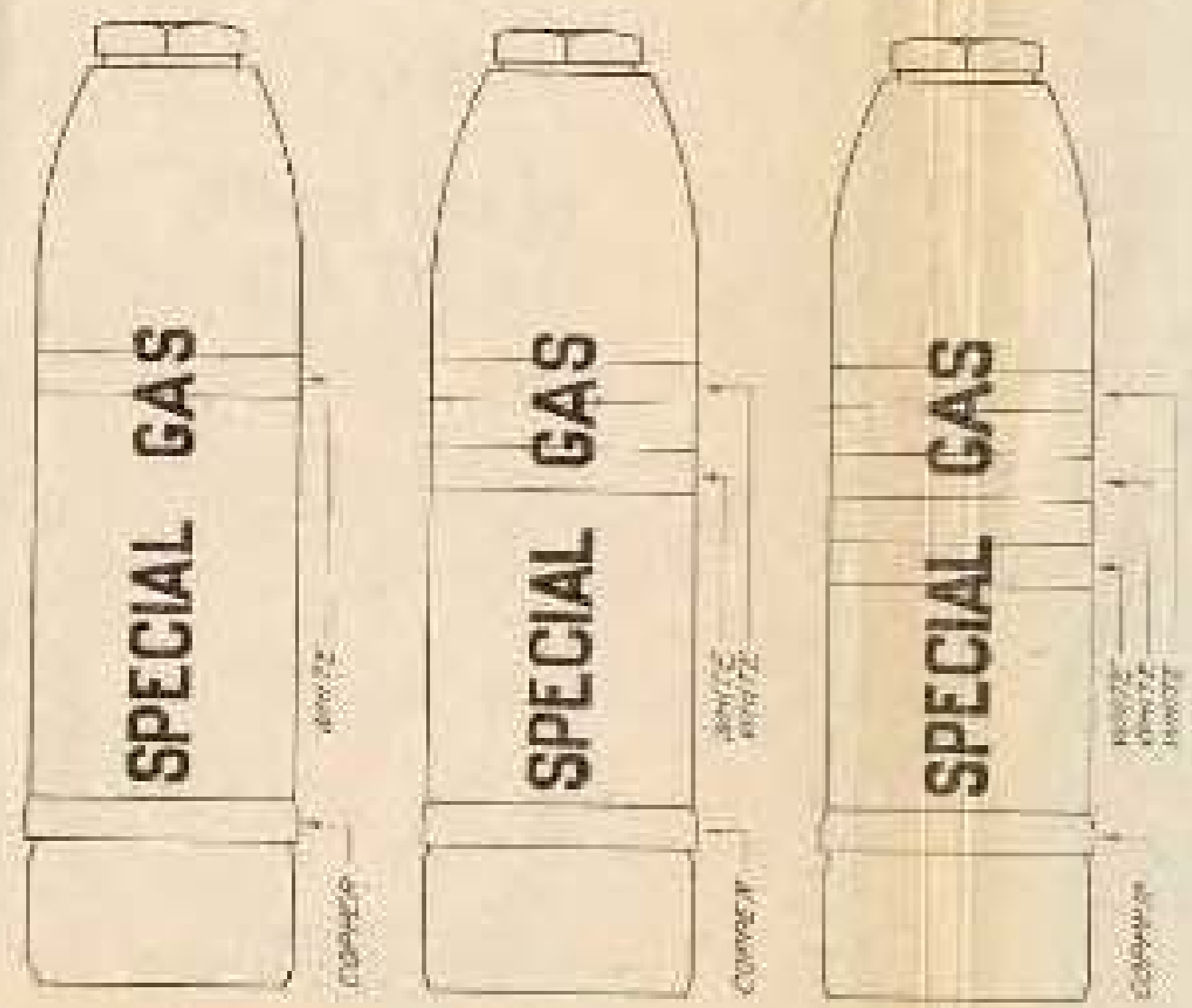
Fig 3  
**AMERICAN CHEMICAL SHELL MARKINGS**

**GAS**

**NON-PERSISTANT  
TOXIC & LETHAL**

**SEMI-PERSISTANT  
PENETRATIVE & SUFFOCANT**

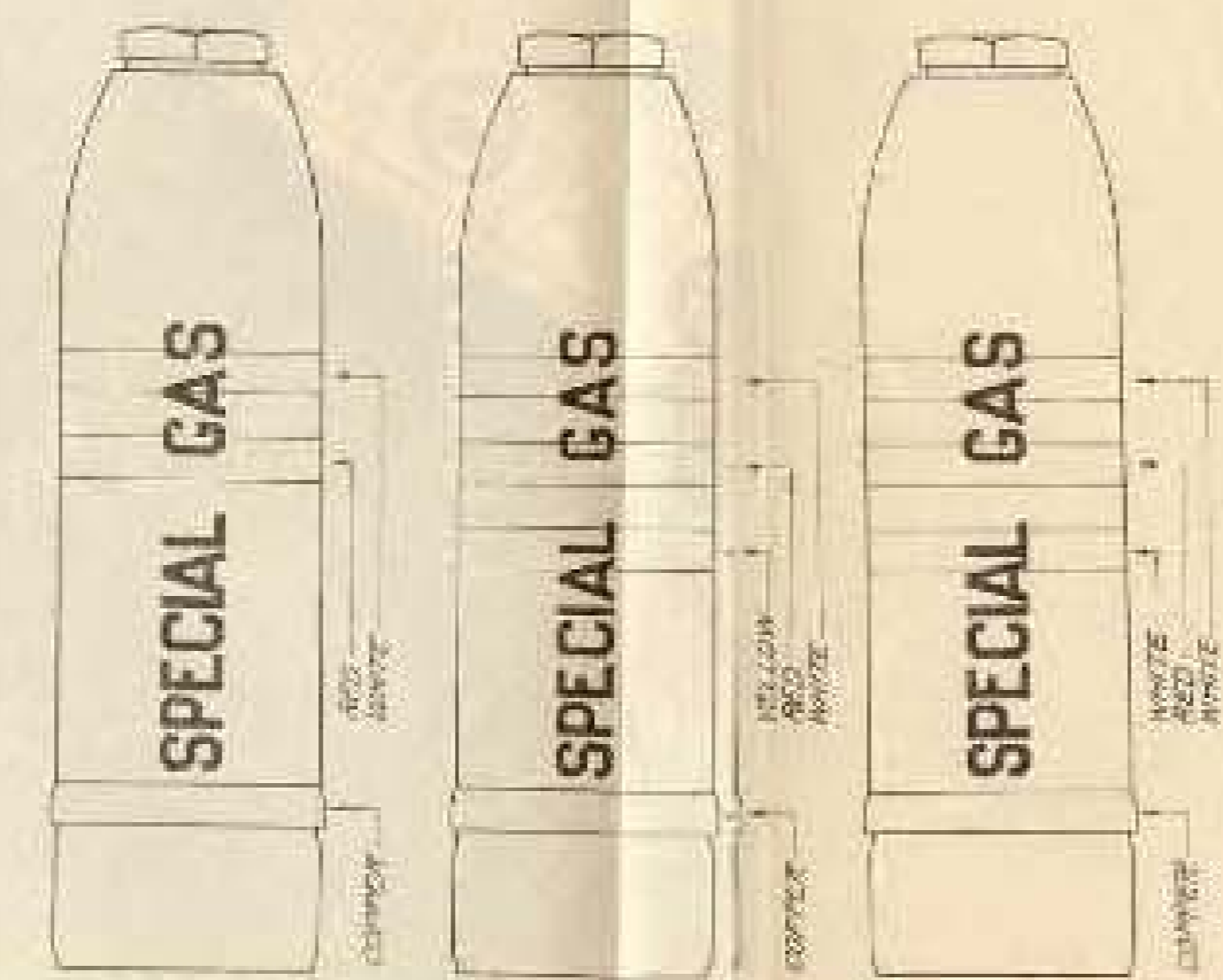
**PERSISTANT  
LACHRYMATORY & VESICANT**



DA

CG

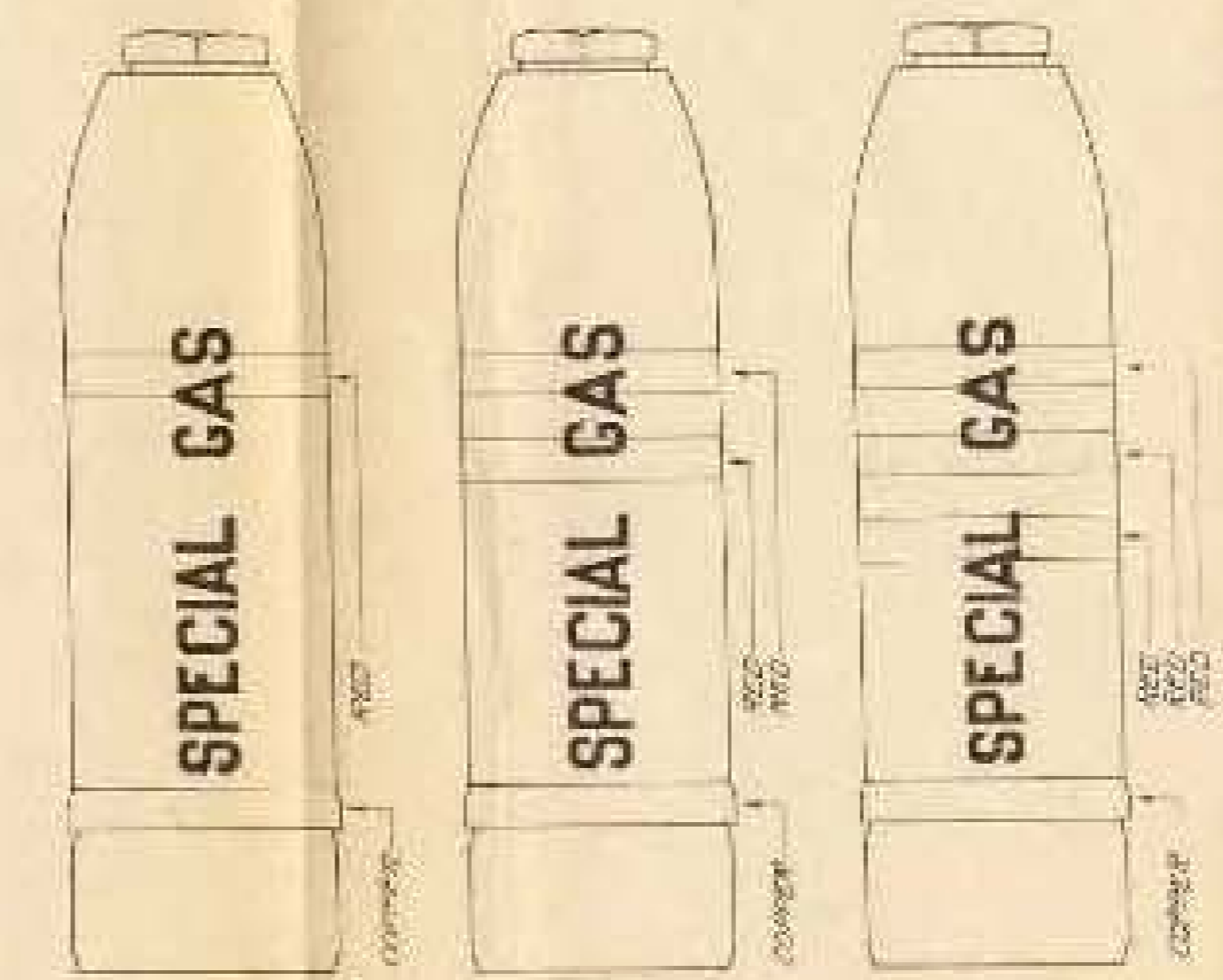
PD



PS

NC

PG



BA

CA

HS

**SMOKE INCENDIARY**

**SOLID**

**LIQUID**



WP

FM

SPECIAL INCEND